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## THE GREAT NEBULA OF RHO OPHIUCHI AND THE SMALLNESS OF THE STARS FORMING THE GROUND WORK OF THE MILKY WAY.

E. E. BARNARD.

FOR POPULAR ASTRONOMY.

Rho Ophiuchi is a fine but wide double star. It forms a beautiful equilateral triangle with two lesser stars, which alone, in a very small telescope, would make it an interesting object. One of these small stars Mr. Burnham has shown also to be double.

In speaking of Rho Ophiuchi, Sir John Herschel describes it as being on "an intensely black back ground in a great blank space." The latter part of this description is true enough, for this star is in one of the most remarkable of the blank regions of the Milky Way. Little however, did Sir John dream, when he spoke of the "intensely black back ground," that Rho Ophiuchi was really the central point of a strong condensation of one of the most remarkable nebulæ in the entire heavens.

For many years this part of the sky troubled me every time I swept over it in my comet seeking; though there seemed to be scarcely any stars here, there yet appeared a dullness of the field as if the sky were covered with a thin veiling of dust, that took away the rich blackness peculiar to many vacant regions of the heavens. This was fully fifteen years ago, at Nashville, Tennessee, when I searched for comets with a five inch refractor.

After going to the Lick Observatory, I still noticed this peculiarity of that part of the sky, and finally found that two small stars north of Antares were involved in nebulosity and that the whole region seemed to be covered with a very weak diluted nebulosity. In reference to this I have a note made in my observing book June 15, 1892, which runs thus: "A couple of years ago, I found two stars involved in very large diffused nebulosity. They are strongly nebulous in the 6½ inch and in the 12 inch, but are best seen in the 6½ inch. The stars are about 8½ and 9½ mag. the following star being the brighter. They are 1°.8 north and 42′ preceding Antares. This region and preceding it for some distance, seems to consist of a vast but very diffused nebulosity."

This part of the sky coming within the sphere of my work in

photographing the Milky Way, on March 23d, 1895, I made a photograph of it with $2^h\ 20^m$ exposure. "The resulting negative showed a vast and magnificent nebula, intricate in form and apparently connected with many of the bright stars of that region including Antares and Sigma Scorpii." See *A. N.* 3301 where an account of this discovery is given.

No mere description can give any idea of the real beauty and singular features of this nebula.

There seem to be three centers of condensation and these are about the stars Rho Ophiuchi, Cordoba D. M. — 24°.12683–4 and 22 Scorpii. The vaster portion condenses about Rho Ophiuchi where it breaks up into enormous clouds. The second condensation is at the Cordoba D. M. stars, and this is the most remarkable. There are four curved streams of nebulous matter running from these stars in different directions which appear somewhat like the whirls of a great spiral. The star 22 Scorpii seems to be in a kind of rift in the nebula with two bright nebulous strips close north and south of it. The bright star Sigma Scorpii has a diffused nebulous extension toward the great nebula of Rho Ophiuchi which can be faintly traced to a connection with the extensions of the large nebula.

Perhaps as remarkable as the nebulosity itself, is the region in which it is placed. The entire nebula occupies a vast vacancy among the stars here, from which great sharply defined vacant lanes run eastward for from ten to twenty degrees. With the exception of the great vacancies, this part of the sky is covered with a uniform sheeting of very small stars, and the lanes which pass eastward from the nebula through these are singularly sharply defined at their borders, especially so in the case of the great south lane. These are entirely devoid of stars with the exception of one or two stray points of light. If these lanes are examined carefully it will be seen that they are not uniformly dark —there are still darker regions in them as if they were filled with feeble nebulosity, in which are holes and rifts, permitting the blacker sky beyond to be seen.

In the upper part of the photograph, the stars B. D. — 19°.4358–9 are seen close together and densely involved in pretty bright nebulosity a half a degree in diameter.

The naked eye star Nu Scorpii is seen to be placed in a large and very remarkable wing like nebula some two degrees in diameter. This nebula at its south west border, is sharply defined but diffuses gradually eastward. It can be traced down to a connection with the nebula about the two B. D. stars some 2° east of

it, and I believe there is strong evidence that these are in turn connected with the great nebula of Rho Ophiuchi. Indeed all this region, for some 50 or 60 square degrees, seems to be involved in a vast diffusion of feeble nebulosity.

There is one peculiarity about this picture, and one which I think is of the highest importance to our understanding of the Milky Way, and to which I have previously called attention, but wish further to emphasize here, and that is the evidence it gives as to the probable smallness of the stars forming the groundwork of the Milky Way.

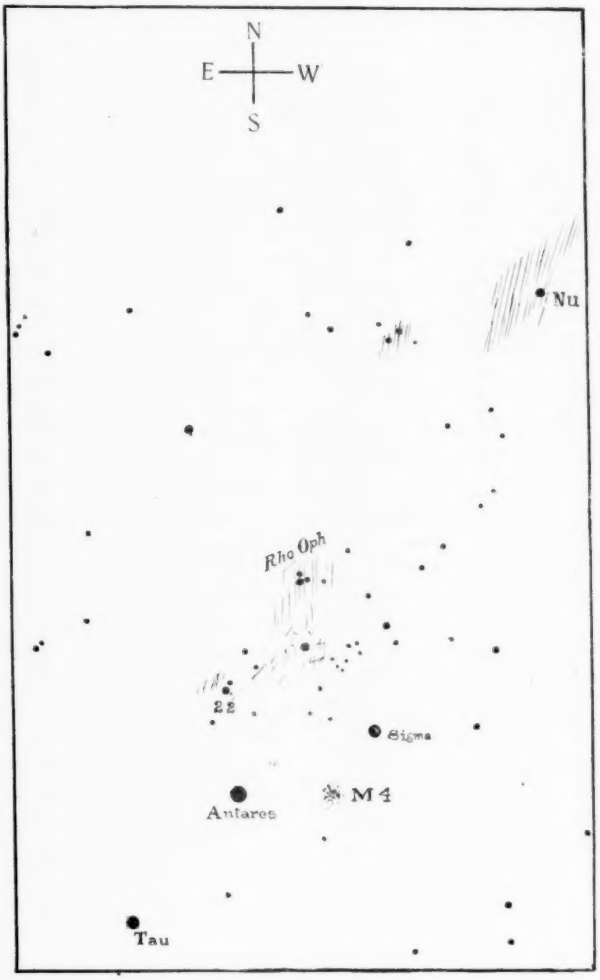
There is certainly no question but that Rho Ophiuchi and 22 Scorpii, and the two Cordoba D. M. stars, are actually involved in the nebula. There is no doubt also but that Sigma Scorpii, at least, of the bright stars of this region, is nebulously connected with the great nebula. I believe I have proof also that even Antares is connected with it. A simple glance at the photograph shows at once that the nebula must be actually mixed up with the ground work of small stars that form this part of the Milky Way. It would seem that this ought to prove conclusively that some of the bright naked eye stars of this region are at essentially the same distance from us as are these small stars of the Milky Way. If these assumptions are true, and I think there is no doubt but that they are, then the seemingly great difference between the naked eye stars here and the apparently very small stars is a real difference and the ground work of the Milky Way at this point is made up of stars that are relatively very small bodies. Now there is every reason to believe that the bright stars in this region are suns comparable with our own in magnitude. Hence the body of the Milky Way is made up of an order of stars vastly inferior to our own Sun. How much smaller they are it would not be safe to estimate, but they must be hundreds and perhaps thousands of times smaller.

The enclosed photograph was made with the Willard lens of the Lick Observatory with two nights exposure viz. June 21-22, 1895, the total exposure being $7^h\ 30^m$. The enlarged copy is intended to show more prominently some of the details that are too small in the original.

In the number of the *Astronomische Nachrichten* referred to (3301) attention was called to a number of other interesting objects shown on the photographs of the Antares region including some new nebulous stars.

As a help to identification of the stars on the photographs, the following positions are given from Frisby's Yarnal catalogue, and are for 1860.0.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rho Ophiuchi = | $Y_3$ 6907 | 7.0 mag. | $\alpha =$ | $16^h$ | $17^m$ | $12^s$ | $\delta = -23°$ 7′ |
| Sigma Scorpii | $Y_3$ 6870 | 2.7 mag. | | 16 | 12 | 41 | $-25$ 15 |
| 22 Scorpii | $Y_3$ 6922 | 7.0 mag. | | 16 | 21 | 29 | $-25$ 50 |
| $\nu^2$ Scorpii | $Y_3$ 6810 | 4.1 mag. | | 16 | 3 | 52 | $-17$ 6 |



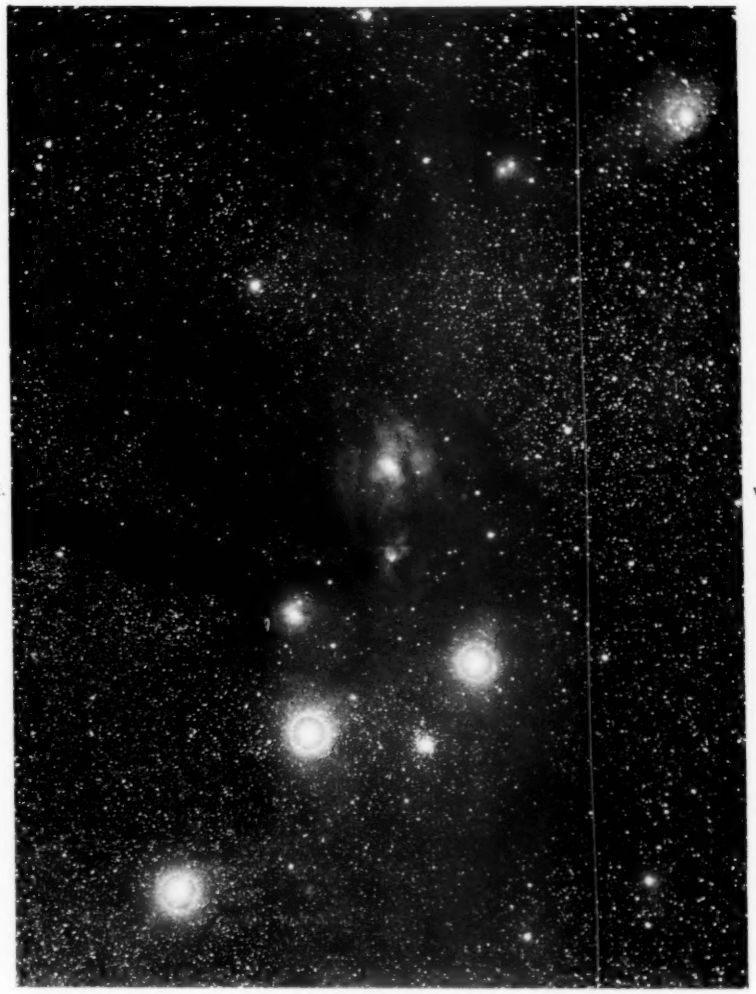

Rough Key Diagram Map of the Stars Near Great Nebula of Rho Ophiuchi.

The stars Cordoba D. M. — 24°.12683–4 are in for 1875.0 $16^h$ $17^m$ 47° — 24° 9′.3 9.6 mag. (the preceding star).

# PLATE XVII.

North.

E.



W

S.

PHOTOGRAPH OF THE GREAT NEBULA OF RHO OPHIUCHI AND VACANT REGIONS NORTH OF ANTARES.

E. E. BARNARD.

Exposure $7^h\ 30^m$, June 21-22, 1895.

The two B. D. stars — 19° 4358–9 and 4361 (the latter of which for 1855.0 is in $16^h\ 12^m\ 1^s$ — 19° 46′) are seen east and south of Nu Scorpii involved in dense strong nebulosity.

If these pictures are successfully reproduced, I think it will be seen that this nebula from its dimensions, its individual peculiarities, and its occupying a region almost devoid of stars—which is the center of great radiating lanes or vacancies among the stars —has scarcely an equal for interest in the entire heavens.

In *Knowledge* for September, 1896, there is an article on this subject, and I may be permitted perhaps, to quote a portion of that article in connection with this and other nebulosities in the Milky Way.

"One feature about this nebula that seems to distinguish it from the other great nebulosities of the Milky Way is the fact that it strongly condenses about the several bright stars * * * and thus shows unmistakably its connection with them. The other great nebulosities seem to be mixed freely with the stars, and not to condense about any individual star.

Even in the case of the condensation of the great nebulosity about 15 Monocerotis, though it is denser at the several bright stars, it does not actually condense *at* any one of these stars.

In its manner of condensation about the bright stars, the great nebula of Rho Ophiuchi resembles the nebula of the Pleiades, for there is an actual condensation at the stars, and not alone a simple involving of them within the limits of the nebula. I have previously called attention to this peculiarity of mixtures of stars and nebulæ in *Astronomy and Astrophysics*.

'There is one point, however—and it may be an important one—where the Pleiades differ from the rest of these nebulous clusters. In its case the nebulosity is condensed about the individual stars; in nearly all the other clusters referred to the nebulosity does not seem to attach itself to any individual star, but simply to involve the group, the stars themselves not showing any special tendency to condensation individually.' I think this peculiarity of condensation or non-condensation is an extremely important one, and well worthy of special attention from those who are interested in such subjects."

In previous articles I have spoken of a small lantern lens 1½ inches with which I made quite a number of photographs of the Antares region besides of other parts of the sky. These photographs clearly show that a vaster portion of this great nebula involves the three bright stars Tau Scorpii, Antares and Sigma Scorpii, and extends some three degrees south and west of

Antares, with a decided condensation about Sigma Scorpii. These features are very noticable in all the photographs of this region with the small lens, they all show that Sigma is involved in a denser part of this diffused nebulosity and that there is a pointed projection extending from Sigma for about one degree north and another running southwest from a half to three-quarters of a degree. Indeed, indications of all these features are shown with the Williard lens also—especially the two prong-like projections from Sigma. The northern of these is the most decided. These are well shown with the shortest exposure with the lantern lens—2 hours 18 minutes, though it has taken the Williard lens seven or eight hours to show the feeblest trace of them.

YERKES' OBSERVATORY, 1897, Aug. 9.

## PARALLAX OF A METEOR DETERMINED BY PHOTOGRAPHY.

J. M SCHAEBERLE AND A. L. COLTON.

FOR POPULAR ASTRONOMY.

At the Lick Observatory on the nights of Nov. 11, 12, 13 and 14, 1896, plates were exposed in two cameras, directed toward the zenith and located about a quarter of a mile apart, in the hope of obtaining simultaneous photographs of meteor trails during the display of the Leonids. A Dallmeyer portrait lens of 6 inches aperture and 32.6 inches focal length, belonging to Hon. W. M. Pierson, was placed at the north-east corner of the roof of the Observatory, and a Willard portrait lens of 5.5 inches aperture and 26 2 inches focus at the U. S. Coast Survey station to the eastward. The cameras were left without change of position or adjustment during the series of exposures. However, the star-trails recorded differed considerably in sharpness of definition from night to night, due to expansion of the wood of the camera-boxes, or other cause. The trails obtained with the Willard lens progressively deteriorated from night to night, while those made with the Dallmeyer lens, always better than the others, seemed to improve slightly. The Dallmeyer lens conspicuously excelled the other in flatness of field.

The exposures were made only in the latter part of the night, after Leo was well above the horizon. On all except the last night they were commenced simultaneously, that the beginnings of the star trails on both plates for a given night might afford

uniform points of reference. The most rapid Cramer "Crown" plates were employed, only one being used in each camera each night. The only meteor trail photographed was obtained on the night of the 13th, the two plates for that night being exposed from $13^h\ 30^m\ 0^s.0$ to $17^h\ 8^m\ 0^s.0$ Pacific Standard Time.

To obtain thoroughly satisfactory results from such observations as this, the distance between the stations should be much greater than was found convenient in the present instance, and the exposures should be made, and the plates developed, under precisely similar conditions. The two lenses should be exact duplicates in dimensions and construction. Then the beginning and the end of a meteor trail as recorded on the two plates would represent with fair accuracy the two points in space through which the meteor passed at the beginning and end of its *photographic* visibility. In the present instance the dissimilarity of the lenses and the inaccurate focus of the Willard lens made this method impracticable. The best expedient seemed to be to find the middle point of the trail, as shown on each plate, and to determine the parallax and distance in space of this point.

On the negative obtained with the Willard lens the meteor trail was about two inches long, and on the other about two and a half; in each case the central point of the meteor trail was two inches more or less, to one side of the center of the plate. The apparent declinations, for the date of exposure, of the stars producing the principal trails were found, and from these data was determined the declination of the central point of the meteor trail on each plate. Three pairs of star-trails, between which this point was located, were used.

On the negative made with the Dallmeyer lens the declination of the point was found to be

| | ° | ′ |
|---|---|---|
| From the inner pair of trails | 35 | 44.2 |
| " " middle " " " | 35 | 44.7 |
| " " outer " " " | 35 | 45.5 |
| Mean | 35 | 44.8 |

And on the other negative

| | ° | |
|---|---|---|
| From the inner pair of trails | 35 | 38 0 |
| " " middle " " " | 35 | 38.2 |
| " " outer " " " | 35 | 39.5 |
| Mean | 35 | 38.6 |

From these means the parallax in declination is therefore 6′.2.

The beginning of a star trail a short distance from the assumed middle point of the meteor trail and in nearly the same declination was taken as a zero-point from which to obtain the parallax

in right ascension. The distance on each plate from this point to the middle point of the meteor-trail, measured in a direction parallel to the star trails, and reduced to the scale of the plate gives:

| | ° | ′ |
|---|---|---|
| For the Dallmeyer negative | 3 | 42.6 |
| " " Willard " | 3 | 36.0 |
| Parallax in right ascension | | 6.6 |

Combining the parallaxes in right ascension and declination we have a total parallax of 9′.06. The distance between the two stations was found to be 1384 feet. As the meteor was quite near the zenith the parallax of 9′.06 corresponds to a distance above the surface of the earth of about 99 miles at the middle point of its visible path.

With a sufficiently long base-line and identical conditions of exposure a case of this kind could be more accurately dealt with by ascertaining the hour-angle and declination of each end of the trail, as photographed at each station. Then the exact position of these two points relatively to the two stations could be found by a simple computation. In the present instance, as already shown, the uncertainties in the results, due to the short base-line and to the difference in the cameras rendered useless a more elaborate treatment.

THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA,
1897, July 27.

## SOME OF THE DOUBLE CANALS OF MARS.

PERCIVAL LOWELL.

FOR POPULAR ASTRONOMY.

In the accompanying plate are a few of the drawings of double canals of Mars made at this Observatory during the opposition which has just passed.

The dimensions of these phenomena are as follows:

Width of each of the double canals 0°.7 to 1°.1 or 25 to 40 miles.

DISTANCE BETWEEN THE CENTRES OF THE TWINS.

| | | |
|---|---|---|
| Cerberus | 4¼° | 155 |
| Triton | 4 | 150 |
| Lethes | 4 | " |
| Amenthes | 4 | " |
| Tartarus | 3⅔ | 135 |
| Laestrygon | 3⅔ | " |
| Erebus | 3⅔ | " |

# PLATE XVIII.

## Double Canals of the Planet Mars.

P. L.

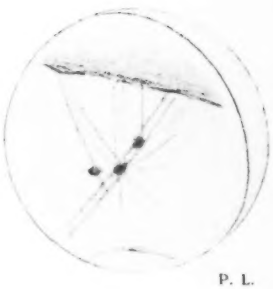
Feb. 24th $3^h$ 48 – $4^h$ 17

Cerberus.
Triton.
Lethes.

P. L.

Feb. 24th $5^h$ 25 – 43

Cerberus.
Triton.
Amenthes.



P. L.

Mar. 1st $4^h$ 38 – $5^h$ 14

Tartarus.
Laestrygon.
Cerberus.
Erebus.

P. L.

Mar. 2nd $4^h$ 18 – 40

Titan.
Cerberus.
Erebus.

P. L.

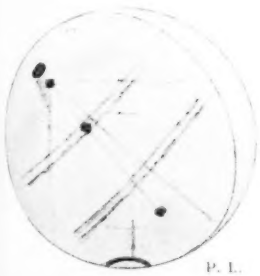
Mar. 4th $5^h$ 5 – 26

Avernus.
New Canal.
Cerberus.
Erebus.

P. L.

Mar. 9th $5^h$ 19 – 34.

Pyriphlegethon.



P. L.

Mar. 13th $4^h$ 44 –59

Medusa.
Steropes.

P. L.

Mar. 26th $4^h$ 27 – 37

Phison.
Euphrates.
Hiddekel.

P. L.

Mar. 26th $6^h$ 8 – 13

Hiddekel.
Gihon.

Lowell Observatory, Mexico, 1897.

| | | |
|---|---|---|
| Titan | 4 | 150 |
| Avernus | 4⅔ | 170 |
| New Canal | " | " |
| Pyriphlegethon | 4⅔ | " |
| Medusa | 4⅔ | " |
| Steropes | 4⅔ | " |
| Phison | 4⅓ | 160 |
| Euphrates | 4⅓ | " |
| Hiddekel | 5 | 185 |
| Gihon | " | " |

Oases 5° to 70°; 185 to 260 miles.

Two points are worth drawing attention to: first, the general uniformity in the width of the separate canals; second, the same with regard to the distance between the pairs.

The doubling of the Hiddekel and of the Gihon is interesting as showing the part played by the well known Forked Bay in this doubling. In fact, the Forked Bay is merely the most salient of the double bays, such as those at the mouth of the Ganges, Phison and so forth, from which double canals start.

With regard to the oases it will be seen that they stretch from one of the twins to the other, the pair entering them at their opposite extremities.

LOWELL OBSERVATORY, Aug. '97.

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## THE STUDY OF THE VARIABLE STARS. VII.

PAUL S. YENDELL.

FOR POPULAR ASTRONOMY.

### 1090 $\beta$ PERSEI (*Algol*). 2.

The most interesting feature of the stars of this type is the character of their light curves—or, to express the same thing less technically, the course of their variations. The characteristic feature of the stars of the type is their continuance at a sensibly constant brightness during much the greater part of their period, a portion which varies from nine-tenths to three-fourths of the whole time; while during the remaining portion they lose a great part of their light, in some cases as much as nine-tenths, and return again to their normal brightness. And this change repeats itself with planetary regularity.

In the case of Algol, the star continues sensibly constant at 2.3 mag. during two and a half days, then decreases, at first gradually, and afterward with increasing rapidity, to 3.5 mag.; that is to say, it loses two-thirds of its light in about four and a half hours; near the time of faintest light, the rate of decrease

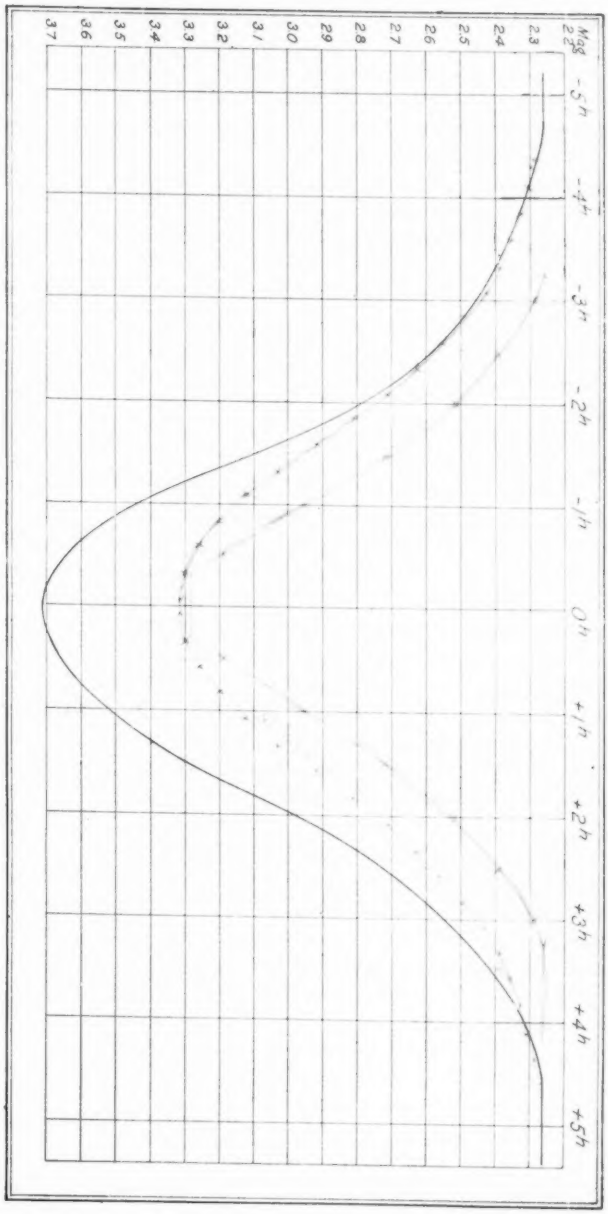
becomes slower, then it halts, and without a pause begins its increase, which continues in very similar manner to the decrease, until at the end of about nine hours from the first diminution of light, it again reaches its normal light of 2.3 mag. And with the exception of the limits of time and magnitude, this description applies generally to all the stars of the type of Algol, excepting some few, which, as in the cases of S Cancri and U Cephei, remain nearly stationary at their minimum light during a very considerable interval between the cessation of the decrease and the begining of the increase.

All the early observers, and those who first interested themselves in the star's elements of variation, confined themselves almost entirely to the determination of its period, and concerned themselves little as to the course of its light-changes. Wurm, it is true, in 1798, stated that the decrease and increase occupied three hours each, and that the star remained at the minimum without sensible change for eighteen minutes; Argelander at first considered this to be the case, but afterwards revised his opinion. This statement, nevertheless, has been handed down from writer to writer, even to Webb, and will probably long survive. The error arose from the fact that the early methods of observing and notation were too rough and crude to take cognizance of the slow change which actually takes place at this phase, which, however, is plainly shown by the method now in common use, which was devised by Argelander in 1842, as noted in the first of these papers (POPULAR ASTRONOMY, May 1896, p. 448).

So far as is known to me, Schönfeld, in a paper* which is still a classic in the literature of the variable stars, and a model for the treatment of such a subject, published in the year 1870, was the first to give the star's light curve serious attention. His paper is too long and detailed to give even an abstract of it here, but from a series of observations made by himself in the years 1864 to 1870, 677 in number, he has deduced a mean light-curve which represents the whole course of the star's variation. About thirty-five of the observations fall during the time of normal light, concerning which Schönfeld says:

"The last seven normals (of five observations each) fall in the full light of the variable; they seem to indicate a slight progression, as though the light reached the absolute maximum $1^d\ 20^h$ after the minimum, and as if the so-called normal light were not a constant phase. Here, however, the probable errors of the

* "Der Lichtwechsel des Sterns Algol im Perseus." *Jahresbericht des Mannheimer Vereins fur Naturkunde*, No. 36, p. 70.




SCHÖNFELD'S MEAN LIGHT CURVE OF ALGOL.

values are greater than their mean differences, and it is also to be noticed that the fourth, which happens to be the highest, is partly made up from the difficult comparisons with $\iota$ Aurigæ, and if these are excluded, we get 20.65 *st.* instead of 21.10 *st.* So that I regard the progression as accidental, and Algol as constant in light at its normal phase."

The accompanying diagram is plotted from Schönfeld's data, only the period of light-variation being included.

In 1882, Julius Scheiner, a pupil of Schönfeld's, and at the time an assisstant at Bonn Observatory, published a discussion of Schönfeld's observations of Algol from 1869 to 1875. The series contains 1605 observations made during the star's minima, and besides these, 357 observations between minima, made with a special view to decide the question of the star's constancy at normal light.

The mean curve, from five hours before to five hours after minimum, is substantially the same as Schönfeld's, nowhere departing from it more than a fraction of a step. The part of the work important for the present paper is the series of normal lights deduced from the series of observations last referred to above: thirty-six normals of ten observations each, from about six hours to two days fifteen hours after the minimum, show an extreme range from 20.23 *st.* to 20.67 *st.*, the mean of all being 20.41 *st.*, and as Scheiner with great justice remarks show "that the full light of Algol . . may be regarded as entirely constant."

In No. 3016 of the *Astronomische Nachrichten*, Plassmann announced that according to his observations, Algol and $\lambda$ Tauri, another star of this type, were not constant in their normal light, and gave numerical values for their light during this phase. In both cases the change noted is very small, being within a single step, and the time intervals are long.

In 1891, he published a small pamphlet, being the third installment of his observations of variable stars. In this he goes into the subject at greater length, and fortunately has given a comparison of his own results with Schönfeld's (Scheiner's discussion, above mentioned), in confirmation of his views; this table is as follows:

| Phase (after min.) h | m | Light (Sch.) | No. obs. | Light (Pl.) | No. obs. |
|---|---|---|---|---|---|
| 7 | 25 | 20.365 | 30 | | |
| 10 | 44 | | | 20.455 | 41 |
| 12 | 20 | .463 | 30 | | |
| 19 | 52 | .355 | 60 | | |
| 21 | 1 | | | .348 | 37 |
| 29 | 48 | .403 | 60 | | |

| Phase (after min.) h | m | Light (Sch.] | No. obs. | Light (Pl.) | No. obs. |
|---|---|---|---|---|---|
| 35 | 57 | | | ·444 | 35 |
| 39 | 50 | ·438 | 60 | | |
| 45 | 43 | | | ·411 | 31 |
| 49 | 20 | ·412 | 60 | | |
| 57 | 11 | ·490 | 30 | | |
| 58 | 30 | | | ·466 | 52 |
| 61 | 45 | ·397 | 27 | | |
| | Mean | 20.410 *st.* | | 20.427 *st.* | |
| Ar. departure from | " | ± 0.032 | | ± 0.037 | |

By comparing the mean brightnesses and the mean departures from them it is at once evident that the difference between the values found by the two observers amounts to a quantity which is not distinguishable by any means at our command; and that the values of the fluctuation shown are similarly evanescent. And upon plotting these values on any usual scale, the impression of constancy conveyed is overwhelming In the case of λ Tauri the announced value of the change is a little greater, but its probability is somewhat vitiated by the statement that one of the comparison-stars used was under suspicion of variability.

In 1894, Pannekock of Leiden published observations of his own, with graphic comparison of the separate years' results with those of Plassmann.

The inflections in the lines representing the course of variation in each year accord neither with Plassmann's nor with each other, and the impression remaining from the whole discussion is strongly to the effect that the supposed fluctuations are not real; that each and all of the series would be at least equally well represented by a straight line; and that the whole amplitude of the indicated change is scarcely enough to be certainly recognizable.

In the *Astronomische Nachrichten*, No. 3385, Professor E. C. Pickering announces the discovery of a similar fluctuation in the normal light of U Cephei, which, as he remarks, was predicted by him fifteen years previously. An inspection of the figures given shows that the entire variation measured only amounts to 0.12 mag. or 0.15 mag., while in his mean curve published in the paper containing the prediction alluded to, and made from observations with the same instrument, he has missed inflections in the light-curve, of greater amplitude, and which have independently forced themselves upon the notice of at least two observers, working by the Argelander method.

Of late years a number of observers have been watching for, and considering that they have found, changes in the light-curves of Algol and of the allied star β Lyræ; but although such change is at least possible, and it is very likely may be actually taking

place, the evidence as yet adduced does not seem to me, in view of the certainty of personal differences between observers, and their uncertain extent and nature, conclusive as to the reality of such changes. In the case of Algol, the writer considers that the weight of evidence is strongly in favor of the star's constancy at its normal light; but there exists a suspicion that the length of the time occupied by its principal variation may be changing; and it is of importance to ascertain if this is the case. Frequent and careful observations, especially at this part of the phase, are very desirable, and sure to be of value.

## PHOTOGRAPHIC ATLAS OF THE MOON.

DR. L. WEINEK.*

My lengthy experience in producing drawings and pictures of lunar landscapes, some with the direct aid of the telescope, others by enlargement from a number of photographic plates of the Lick Observatory (vide: Astronomische Beobachtungen an der k. k. Sternwarte zu Prag von 1884, 1885—87, 1888—91 "and in Vol. III of the "Publications of the Lick Observatory" ("Selenographical Studies" p. 1—130) has supplied me with the materials for undertaking with every prospect of success the following work, which claims to produce an accurate and artistic representation of the whole visible surface of the Moon. That photography is the only means by which the task can be accomplished is very clear. Only its aid can avail to elminate the disturbing factors arising from the observer's personal equation, deficient grasp, erroneous interpretation; it alone can obviate the inaccuracies attendant on a method of arriving at a result by piecing together step by step the data of observation noted down by the hand and only its use is capable of finishing a labor of the present magnitude within a comparatively short space of time. A wide experience in photography, moreover, reaching back to the years 1873 and 1874 has materially assisted me in carrying out the plan. In the year 1873 the temporary trial station erected at Schwerin for the photographic observation of the transit of Venus in 1874 was entrusted to my management and control; whilst on December 9, of the year following, astronomical and photographical observations of that phenomenon were carried out by myself with complete success on the Island of Kerguelen in the south of the Indian Ocean.

* Director of the Imperial and Royal Observatory of Prague.

Dissatisfied with the photographic enlargements made by experts in various quarters I began on April 19, 1893, a series of experiments with a view to discover a method which, while rendering the minutest details with absolute exactness and accuracy, might at the same time ensure a plastically perfect and beautiful delineation of the object portrayed. That method I flatter myself to have now found. I intend to publish in the immediate future an account of that method and hence I content myself at this stage with quoting the opinions of a few competent critics on my photographic lunar enlargements which were copied on chloride of silver paper and have been sent to a large number of Academies and Observatories.

Professor E. S. Holden, Director of the Lick Observatory who has carefully examined and compared the lunar photographical enlargements published hitherto by various Selenographers, thus concludes in the "Publications of the Astronomical Society of the Pacific" Vol. III, No. 53, 1896, p. 321: "It (this comparison) appears to show conclusively that the silver-prints of Professor Weinek (X-foot scale) come nearer to technical perfection than any other, in that they most successfully reproduce the grain of the original negative and therefore are best fitted to show the finer details of the lunar surface;" and p. 323. "The effort of Professor Weinek has been to reproduce the minutest particulars of the original negative; and he has certainly accomplished this end."

M. Loewy, Director of the Paris Observatory, in the Comptes Rendus of the 10th of August 1896, p. 349, speaking of my lunar photographical enlargements sent to the Academy of Paris, observes: "Many times already we have had occasions to place before the eyes of the Academy important collections of enlargements on paper executed with great talent by Doctor Weinek, which have enabled him to point out many objects which have escaped the attention of Selenographers."

Dr. A. A. Common, President of the Royal Astronomical Society in London stated emphatically in the meeting of the 10th of April of that learned Society ("The Observatory," May 1895, p. 179:) "The enlargements of the Paris photographs made by Doctor Weinek appear to me to be the most wonderful things which have been done in lunar topography up to the present time. They surpass everything yet done."

The materials that form the basis and bulk of the Photographic Lunar Atlas, began by me in 1894 and now almost completed, are mainly derived from the Lick Observatory. The contribu-

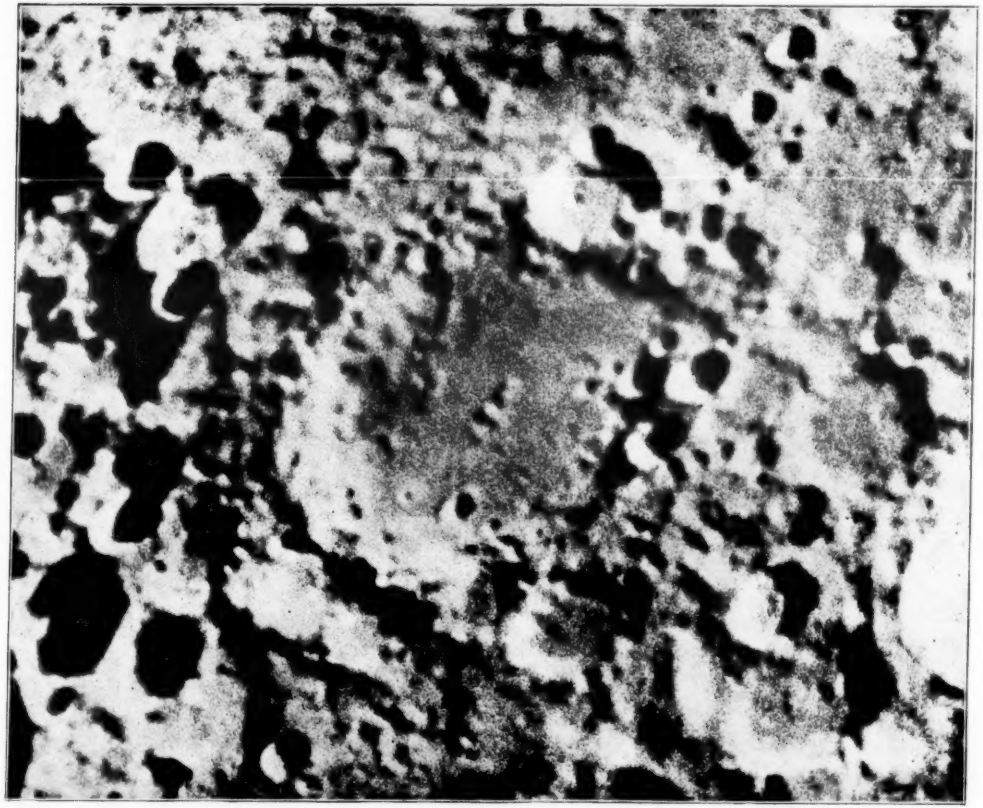
tions from that source consist of 94 exquisite negatives including the various phases of a whole lunation, taken at the focus of the telescope of 36 in. aperture of that Observatory during the years 1890—1896, and of about 140 diapositives of the same size, for which I am indebted to the generosity of Professor E. S. Holden, who takes the highest interest in the development of Selenography. To that must be added 4 striking lunar negatives made by Messrs. Loewy and Puiseux at the focus of the large Equatorial Coudé (of 60 *cm* aperture and 18 *m* focal length) of the Paris Observatory, and 2 excellent lunar diapositives of the Arequipa branch-station of the Observatory of Cambridge, (Mass.), taken by Professor Bailey with the telescope of 13 in. aperture and enlarged with an ocular placed near the focus. For the first I am indebted to the obligingness of M. le Directeur Leowy; for the last to the kindness of Professor E. C. Pickering. Hence as a matter of course my Photographic Lunar Atlas had to be based essentially on the lunar negatives of the Lick Observatory; whilst the appended enlargements of Paris and Arequipa plates are joined chiefly for the purpose of facilitating comparative study.

The scale I adopted in enlarging the Lick negatives is uniformly 24 times the original, whilst the scale of enlargement of the Paris negatives and Arequipa diapositives is slightly less. For the first the factor of enlargement remained constant, because the distance between the original and the Plate of the photographical enlargement, by the same optical arrangement, remained constantly the same and corresponds, at the mean distance of the Moon from the Earth, to a lunar diameter of 10 feet (= 3,1 *m*, 1 *mm* = 1,1 *km* = 0,″6). For the last there is a slight modification in the factor of enlargement from one Plate to the other, so that the result in every case gives a diameter of 4 Metres (1 *mm* = 0,89 *km* = 0,″48) i. e. the double of the diameter of Schmidt's Map. In enlarging the focal plates 24 times, one brings out to the naked eye and without any difficulty, the smallest details of the lunar surface, while its plastic beauty is not altered, and in the second, a simple ratio with the map of Schmidt is maintained. The following instance will help to illustrate this remark (see: Imp. Academy of Sc. of Vienna, Sitting of the math.-physical Class of the 13th of February 1896). On the photographical enlargement (24 times) from a Lick Negative June 27, 1895, $8^h$ $21^m$ $1^s$ P. S. T. I discovered, on January 10 1896, on the top of the mountain in the north-western part of the interior of Cyrillus, a small, round object like a crater of 1,1 *km* in diameter. I at once

Popular Astronomy No. 45

From Moon Atlas, by L. Weinek.

PLATE XIX.



MAGINUS.

FROM LICK OBSERVATORY NEGATIVE, 1895 OCTOBER 9, $16^h\ 20^m\ 2.0^s - 2.5^s$ P. S. T.

From Moon Atlas, by L. Weinek.

communicated my observation to the French Selenographer C. M. Gaudibert of Vaison (Vaucluse) and sent him at the same time the print containing it. On the 20th of January 1896 he was able to confirm, without any possible doubt, the reality of the existence of this crater on that mountain, with his telescope of 260*mm* aperture. The diameter of that crater is 1 *mm* on the print, and it would hardly be visible to the naked eye, were the enlargement made on a smaller scale.

The work of enlarging from the above focal Plates went on up to Easter 1897. From April 19 to December 1 1893 100 photo-lunar enlargements were made; most of these are of the size of 13 × 18 *cm*; and they come from diapositives; they comprise experiments of the utmost variety. From December 1 1893 up to Easter 1897 I made 485 photo-lunar enlargements from original Negatives only, (with the exception of 7 enlargements taken from two Arequipa diapositives), and of the size of 21 × 26 or from 26 × 31. From among these the first 196 were made by myself with an assistant for the development of the plates etc.; the last 289 were executed (since November 1894) by myself alone in all the stages of their execution. The last mentioned enlargements, based too on more favorable original negatives, were the first to give complete satisfaction. Funds to defray the very considerable outlay for plates, in pursuing this lengthy and laborious work, were provided, partly by a Government grant and a grant from the Vienna Academy of Science, partly by the munificence of private donors, especially by Baron Albert von Rothschild in Vienna, and Miss Catherine W. Bruce in New York.

And now that the principal part of this preparatory work is done, the plan is to publish at Prague a Lunar Photographic Atlas on a scale of 10 feet, relatively 4 metres to the diameter of the Moon, having 200 maps of the size of 26 × 31 *cm* containing the principal lunar formations viewed under the most varied conditions of illumination. If this Atlas is favorably received, I purpose to publish, later on, a second series of 200 maps to complete the first. The 200 maps first mentioned come from enlargements made since November 1894 and show the best of what has been done up to the present time. The order in which the pictures will be arranged must not be supposed to follow the phases of the waxing or waning Moon; it will much rather be determined by the degree of excellence or of beauty exhibited in the enlargements available for publication. Shown at the top of each sheet will be the selenographical latitude and longitude for the centre of the picture, and also the selenographical longitude of

the terminator for the latitude 0°. By this means it will be easy for every one to arrange the sheets according to the relative positions of the lunar objects they portray or according to the terminator of the corresponding lunar phase. To secure the utmost precision in the minutest details, the reproductions of enlargements done at Prague will be executed by the phototype in a manner as closely approaching perfection as possible. They will be printed straight from my enlarged glass-diapositive, under my constant personal supervision and control, by the well known Art.-Photographical Institute of Carl Bellmann, Prague. The enclosed print* showing the Maginus Walled Plain (L. O. 1895, Oct. 9, $16^h\ 20^m\ 2^s$ —2,5 P. s. t.) is an example of the way in which each map will be printed on card board of the size of 23 × 43 *cm*, so that they may be easily handled at the telescope or framed for scientific collections. Each map will be detached and one fascicule containing 20 maps will appear every 2–3 months. This will obviate the difficulty that Observatories, Academies, Scientific Societies and Institutions might else find in purchasing the entire work in one issue.

All the laborious work I have incurred, all my self-sacrifice and devotion to the cause of science will be of little avail to the public, and the publication of the Atlas in the dimensions proposed (10 issues making a total of 200 lunar landscapes) can not be undertaken, until the requisite pecuniary support is forthcoming in the shape of promises of numerous subscribers to the work. I venture to appeal in the first instance to the various Observatories at home and abroad and to solicit their promises to become subscribers for the 10 issues each to contain 20 lunar landscapes.

Pursuing, as I do, different ends from those of the Paris Lunar Atlas (its diameter of nearly 2½ metres makes it a little larger than Schmidt's map) which aims at securing great beauty of relief and plastic effect, as well as from those of the Mt. Hamilton Atlas (its diameter is equal to that of Mädler's Map i. e. one metre), which endeavors to preserve the faint contrasts of light and shade in their true value (vide: "Publications of the Astronomical Society of the Pacific," Vol. VIII, N. 53, 1896, p. 319–324,) my enlargements published in the Prague Lunar Atlas should have ample justification for publication, in that they will together afford a faithful and accurate reproduction of the striking results obtained in the field of Photoselenography at the end of the XIX century.

Prague, April 18, 1897.

* Plate accompanying this article.

## ON A NEW BINARY STAR WITH A PERIOD OF 5 1-2 YEARS ($\beta$ 883.)

T. J. J. SEE, A.M., PH. D.

For several months I have been practically certain that the double star $\beta$ 883 = Lalande 9091, $\alpha = 4^h\ 44^m\ 33^s.0$, $\delta = +10°\ 52'$ (1875.0) is revolving in a period of about 5.5 years, and thus describing its orbit in less than one-half the time required for the most rapid system heretofore known; but it seemed desirable to withhold any announcement of such an extraordinary result until the observations should remove every reasonable doubt of the correctness of the conclusion. Indeed, this hypothesis first presented itself to my mind in the summer of 1895, when I was examining the orbits of all known binaries with a view to selecting those most accurately determined for incorporation into the work recently published (*Researches on the Evolution of the Stellar Systems*, vol. i ).

Professor Schiaparelli had very kindly communicated by private letter a number of his unpublished observations of this star, and on combining these with other measures in my possession it seemed clear that only a period of about 5.5 years would satisfy the observations. Professor Burnham, however, did not regard the evidence as conclusive, and I decided to wait till further measures were available. On entering upon the measurement of southern double stars I felt that notwithstanding the northern position of this object the great interest attaching to it would justify occasional examination with the Lowell 24-inch refractor. Accordingly I observed it at Flagstaff in September, and have since continued the observations every month, except when the Observatory was in process of removal to Mexico. These observations since 1896 September furnish the key to the situation; and as the Sun is now rapidly overtaking the star, and it cannot be followed much longer this year, the present is a favourable time to present to the Society the results at which we have arrived. In the sweeps for new double stars I am assisted by Mr. W. A. Cogshall, S.B., who generally examines all objects of difficulty, and at different times has secured a considerable number of measures. His work has been done with care and precision, and I have valued his judgment in all cases of doubt. In our observations of this star we are in entire accord.

INDIVIDUAL OBSERVATIONS OF $\beta$ 883.

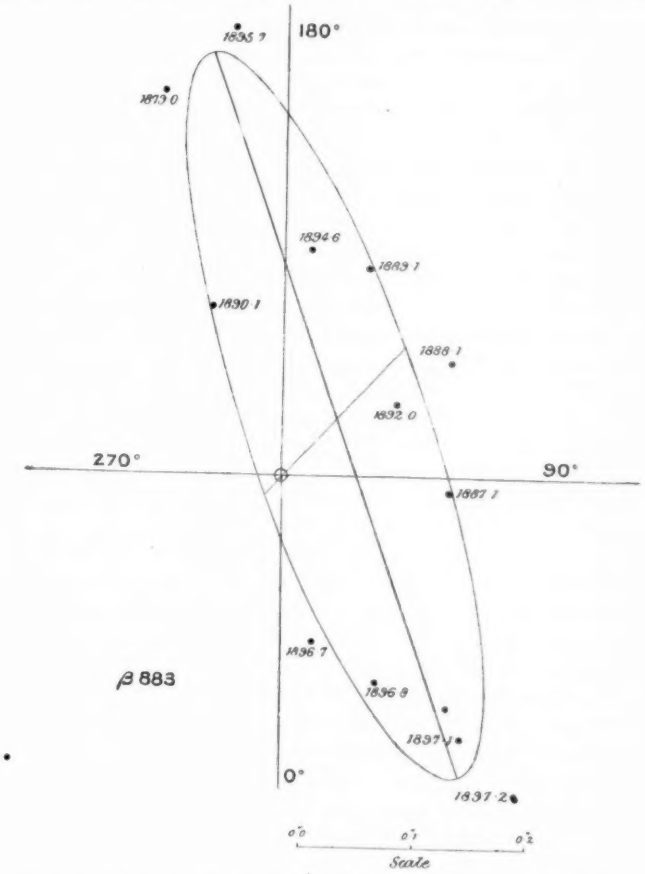
| $t$ | $\theta_0$ ° | $\rho_0$ ″ | Observers. | Remarks. |
|---|---|---|---|---|
| 1879.00 | [197.5] | 0.35 | Burnham | |
| | 17.5 | | | |
| 1887.096 | 84.3 | 0.15 | Schiaparelli | Very difficult. |
| .170 | 85.0 | 0.15 | " | " " |
| .172 | 84.7 | 0.15 | " | " " |
| 1888.055 | 119.5 | 0.18 | " | |
| .066 | 129.4 | 0.18 | " | |
| .142 | ... | ... | " | Simple. |
| 1889.017 | 137.0 | ... | " | Doubtful. |
| .065 | ... | ... | " | Simple. |
| .176 | 158.8 | 0.15 | " | |
| .192 | 158.3 | 0.20 | " | |
| .195 | 144.2 | 0.25 | " | + 180°.0 ? |
| 1890.130 | 200.7 | 0.15 | " | Doubtful. |
| .132 | 206.9 | 0.15 | " | " |
| .149 | 202.8 | 0.18 | " | " |
| 1891.14 | Single | Many nights | Burnham | |
| .146 | ... | ... | Schiaparelli | Single. |
| .149 | ... | ... | " | " |
| .785 | 125.2 | 0.12 | Burnham | |
| 1892.057 | 116.4 | 0.06 | " | |
| .060 | 127.8 | 0.12 | " | |
| 1893.072 | ... | ... | Schiaparelli | Single. |
| 1894.146 | ... | ... | " | " |
| .165 | ... | ... | " | " |
| .65 | 173.5 | 0.20 | Barnard | |
| 1895.146 | ... | ... | Schiaparelli | Uncertain. |
| .745 | 186.0 | 0.43 | See | Good images. |
| .746 | 186.8 | 0.35 ± | " | Separated. |
| .745 | 188.9 | ... | Moulton | " |
| 1896.692 | 9.9 | 0.17 ± | See | Distinctly elongated, but no trace of separation. |
| .693 | 12.0 | 0.14 ± | " | |
| .728 | 28.7 | 0.25 ± | " | Elongated, but not separated. |
| .843 | 22.8 | 0.18 ± | " | Elongation very distinct. |
| .844 | 23.8 | 0.17 ± | " | Notched under power of 1000. |
| 1897.028 | 34.6 | 0.28 ± | " | Well separated, but very close. |
| .118 | 34.2 | 0.28 | " | Distinctly separated. Good measures. |
| .162 | 35.5 | 0.25 | " | Nicely separated. |
| .162 | 36.0 | 0.35 | Cogshall | |
| .192 | 37.8 | 0.35 | See | Distinctly separated, with black line between. |
| .193 | 37.1 | 0.35 ± | " | Distinctly separated, with black line between. |
| .192 | 35.5 | ... | " | Angle certainly not smaller than this value. |

In September last the star was moderately elongated in angle 11°, but no trace of separation could be seen, though examined under good seeing with a power of 1000; now it is distinctly separated with a black line between the components, with a power of only 500, and cannot be regarded as a very difficult object for the great telescope.

The distance at present can hardly fall short of 0″.32, while in September it certainly was not more than half this value.

This object was discovered by Burnham with the Chicago

18½-inch Clark refractor in 1879.0, and measured on one night. The components of the close pair (there is a third component in 152°.2, 18″.22, 13th magnitude) have always been noted as




nearly equal (generally as 7.8 and 8), differing at most by one or two tenths of a magnitude; and hence I suspect that the first angle given as 17°.5 ought to be increased by 180°. If the stars are sensibly equal the observers almost involuntarily adopt the smaller of the two possible position-angles. Our recent observations give an additional ground for this correction by showing that the stars are not separated in angle 17°.5, and hence it is improbable that the distance would have been given as 0″.35.

The observations of Schiaparelli in 1887, 1888, 1889, 1890, show that the motion is rapid, and indicate that the period is only a few years. In 1891 the star was single to Schiaparelli and also to Burnham, who examined it on several nights; which would imply that the companion was then in periastron. In 1891.97 it was observed by Burnham, who concluded that 100° had been swept over by the radius vector since 1879.0. In 1894.65 Professor Barnard observed it, at my request, and found the angle to be 173°.5. While observing double stars at Madison in September 1895, I took occasion to measure this object, and found that it was close, but nicely separated with the 15½-inch refractor.

Mr. Moulton's measure was in substantial agreement with my own, and neither of us regarded it as a very difficult object for a good telescope. I have no record of any subsequent measures until the beginning of our work at Flagstaff. In September it certainly was slightly elongated, but not a trace of separation could be seen. In our subsequent observations we were equally unable to get evidence of separation until November 4, when with a power of 1000 and good seeing there appeared for the first time some evidence of "notching." As soon as observations were begun in Mexico I took occasion to examine this object. It then appeared for the first time actually separated, though still very close. In the subsequent observations the object became easier and easier, until now the star is well separated with a black line between the components, and the division can be seen with comparative ease even if the observer has little experience or the seeing is not the very best. We estimate the seeing on a scale of 10; that at Flagstaff was uniformly rated at 7; here in Mexico it has been rated at 4 and 5. The atmospheric conditions here were certainly not so good as those at Flagstaff.

Under these circumstances I do not hesitate in the belief that the companion has recently passed periastron, and that we have observed it widen out from month to month, until it is now within the reach of moderate-sized telescopes. I have, therefore, investigated the general nature of the orbit, and herewith submit an approximate set of elements, which will be sufficiently exact for the use of observers.

The following considerations enable us to derive the essential elements of the apparent orbit.

1. The motion since 1895.7, over an arc of 210°, indicates that the period will be very short, probably not far from five years; the observations of Schiaparelli point to a similar conclusion,

and hence if we take the angle in 1879.0 to be 197°.5 we may conclude that three revolutions have been performed between that date and 1896; whence we deduce a period of about 5.5 years. All the observations are consistent with such a period except that of Burnham in 1891.97, where the angle appears to be in error about a quadrant. On inquiring of him whether there could be an error in the reduction of the angle, he writes that he does not think there can be an error of a quadrant in the published measure.

We shall at present make no attempt to assign the cause of the discrepancy. The other observations indicate an error of some kind, and we must either reject the one observation or all others combined.

Even if all the other observations be discarded there will still be a case of rapid motion, as the angle is now 90°, or 270° different from that recorded in 1891.97.

2. The elements of the orbit are as follows:—

$P = 5.5$ years $\quad a = 0''.621$
$T = 1896.40 \quad \nu = 20°.6$
$\varepsilon = 0.760 \quad i = 82°.52$
$\lambda = 273°.83$

Apparent orbit:—

| | |
|---|---|
| Length of major axis | $= 0''.67$ |
| Length of minor axis | $= 0''.16$ |
| Angle of major axis | $= 19°.5$ |
| Angle of periastron | $= 318°.0$ |
| Distance of star from center | $= 0''.07$ |

The apparent orbit shows the general nature of the motion, and indicates very decidedly that the period cannot much surpass 5.5 years, and that the eccentricity and inclination are very high.

COMPARISON OF COMPUTED WITH OBSERVED PLACES. $\beta$ 883.

| $t$ | $\theta_o$ | $\theta_c$ | $\theta_o - \theta_c$ | $\rho_o$ | $\rho_c$ | $\rho_o - \rho_c$ | $N$. |
|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ″ | ″ | ″ | |
| 1879.00 | 197.5 | 191.0 | + 6.5 | 0.35 | 0.37 | − 0.02 | 1 |
| 1887.15 | 84.7 | 54.9 | + 29.8 | 0.15 | 0.21 | − 0.06 | 3 |
| 1888.06 | 124.4 | 130.2 | − 5.8 | 0.18 | 0.15 | + 0.03 | 2 |
| 1889.14 | 158.5 | 179.2 | − 20.7 | 0.20 | 0.31 | − 0.11 | 4 |
| 1890.14 | 203.4 | 195.5 | + 7.9 | 0.16 | 0.30 | − 0.14 | 3 |
| 1891.14 | single | 22.4 | ... | ... | 0.24 | ... | 1 |
| 1891.15 | " | 22.4 | ... | ... | 0.24 | ... | 2 |
| 1891.97 | 33.1 ?<br>123.1 | 36.1 | − 3.0 ? | 0.12 | 0.30 | − 0.18 | 3 |
| 1893.07 | single | 80.1 | ... | ... | 0.16 | ... | 1 |
| 1894.65 | 173.5 | 178.8 | − 5.3 | 0.20 | 0.31 | − 0.11 | 1 |
| 1895.15 | uncertain | 190.9 | ... | ... | 0.37 | ... | 1 |
| 1895.74 | 186.4 | 193.3 | − 6.9 | 0.39 | 0.35 | + 0.04 | 2 |
| 1895.74 | 188.9 | 193.3 | − 4.4 | ... | 0.35 | ... | 1 |
| 1896.692 | 11.0 | 23.3 | − 12.3 | 0.15 ± | 0.25 | − 0.10 | 2 |
| 1896.805 | 25.1 | 25.3 | − 0.2 | 0.20 ± | 0.31 | − 0.11 | 2 |
| 1897.073 | 34.4 | 29.6 | + 4.8 | 0.28 | 0.31 | − 0.03 | 2 |
| 1897.162 | 35.5 | 31.0 | + 4.5 | 0.25 | 0.31 | − 0.06 | 3 |
| 1897.162 | 36.0 | 31.0 | + 5.0 | 0.35 | 0.31 | + 0.04 | 1 |
| 1897.192 | 37.5 | 31.4 | + 6.1 | 0.35 | 0.31 | + 0.04 | 2 |

3. It is now clear that Mr. Burnham's supposition, that the motion from 1879.00 to 1892 amounted to 100°, fell far short of the truth. At that time it must have amounted to about two and one half revolutions. For during the interval since 1892 the companion has swept over an arc of 270°; even if it were admissible to suppose that it is now in the third quadrant instead of the first (indicated by our observations), we should still have a motion of 90° since 1892, which contradicts the hypothesis of slow motion. Supposing that only 90° have been described since 1892, the slow motion hypothesis is contradicted by the observations of Schiaparelli in 1887, 1888, 1889, and by our inability to see the pair separated in 1896 with the 24-inch, whereas the object was easily divided in 1895.7 with a 15½-inch telescope. Also, if the motion is slow the minimum change which can have taken place since 1892 (90°) requires that the orbit should be much extended in the first quadrant, and hence the star would have been wide and easy at the time of Schiaparelli's observations; he actually found it close and difficult and, except in the first case, in the second and third quadrants. It is, therefore, clear that the motion of this system is very rapid, and that no other hypothesis will explain the phenomena.

The results here submitted give only a first approximation to the orbit, and doubtless some improvement of the elements will soon be possible. This remarkable object ought to be followed from month to month during the whole time it is visible. By securing a closely connected series of observations we shall soon be able to render the orbit very exact.

The discovery of an object revolving in a period of 5 5 years is an achievement of some philosophic significance in the history of double star astronomy. In the time of Sir John Herschel the most rapid of known binaries was ζ *Herculis*, with a period of 35 years. Twenty years ago the remarkable object 42 *Comæ Berenices* had reduced the shortest period to about 25 years, and in 1887 δ *Equulei* brought it down to 11.5 years. κ *Pegasi* (β 989) has since been shown to revolve in a similar period.

In β 883 we have for the first time a visible binary with a period fairly approaching those of the spectroscopic binaries recently discovered, and we seem assured that at last a link has been found connecting the two classes of objects. It is probable that other stars will disclose even shorter periods, for there is no reason why there should not be close doubles with periods of a single year or less. It will be an interesting object of future research to fill in the intervening steps between visible binaries

with periods of a few years and the spectroscopic binaries revolving in a few days or months.

The more critical inquiry into the motion of close doubles will commend itself to the attention of double star observers with great telescopes, and on the other hand it may be hoped that the study of the relative motion in line of sight of the components of binaries like $\beta$ 883 will be taken up on some of our great observatories equipped with powerful spectroscopic appliances.

LOWELL OBSERVATORY, CITY OF MEXICO:
1897 March 12.

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Since the above paper was forwarded to the Secretary I have received from professor Barnard full details of his observations in 1894. These measures are very important, and since they are not all included in the above list, they are here condensed.

| $t$ | $\theta_0$ | $\rho_0$ | Remarks. |
|---|---|---|---|
| | ° | ″ | |
| 1894.649 | 173 5 | 0.20 | Seeing 4 (scale of 5); the stars are north and south; power, 1500. |
| 1894.668 | 176 8 | 0 20 | Seeing, 4 — 5; power, 1500. |
| 1894.671 | 178.7 | 0.16 | Seeing, 5; power, 1500. Stars very close. |

The instrument used was of course the 36-inch refractor.

These measures leave absolutely no doubt of the rapid motion between 1892 and 1894, and are therefore in accordance with the results given in the foregoing paper.—*Monthly Notices, No. 8, June, 1897.*

LOWELL OBSERVATORY, CITY OF MEXICO: 1897, April 7.

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## THE TOTAL ECLIPSE OF THE SUN, JANUARY 22, 1898.

DR. H. C. WILSON.

This eclipse will not be visible in America, but will be visible as a partial eclipse over the greater part of the Eastern Continents. The path of the total eclipse is only about 57 miles wide, beginning in the heart of Africa, in the Soudan, crossing the Arabian Sea, entering India about 150 miles south of Bombay, thence passing toward the northeast across China to the southern boundary of Siberia. The eclipse begins January 21 at $16^h\ 45.9^m$ Greenwich mean time, in longitude 21° 39′ east from Greenwich, latitude 0° 29′ north, and ends Jan. 21 at $21^h\ 52.6^m$ in longitude 110° 4′ east, latitude 35° 37′ north. Central eclipse begins, i. e. the center of the *umbra* of the moon's shadow touches the Earth

first at $17^h$ $48.7^m$, in longitude 9° 50′ east and latitude 11° 11′ north. Central eclipse ends, or the center of the Moon's shadow leaves the Earth at $20^h$ $49.7^m$ in longitude 119° 6′ east, latitude 45° 47′ north. The duration of totality at any one place is only $2^m$ $19.4^s$ at the greatest, a very short time in which to make the delicate observations which the astronomers desire, in order to solve the important problems connected with the constitution of the Sun and its immediate surroundings.

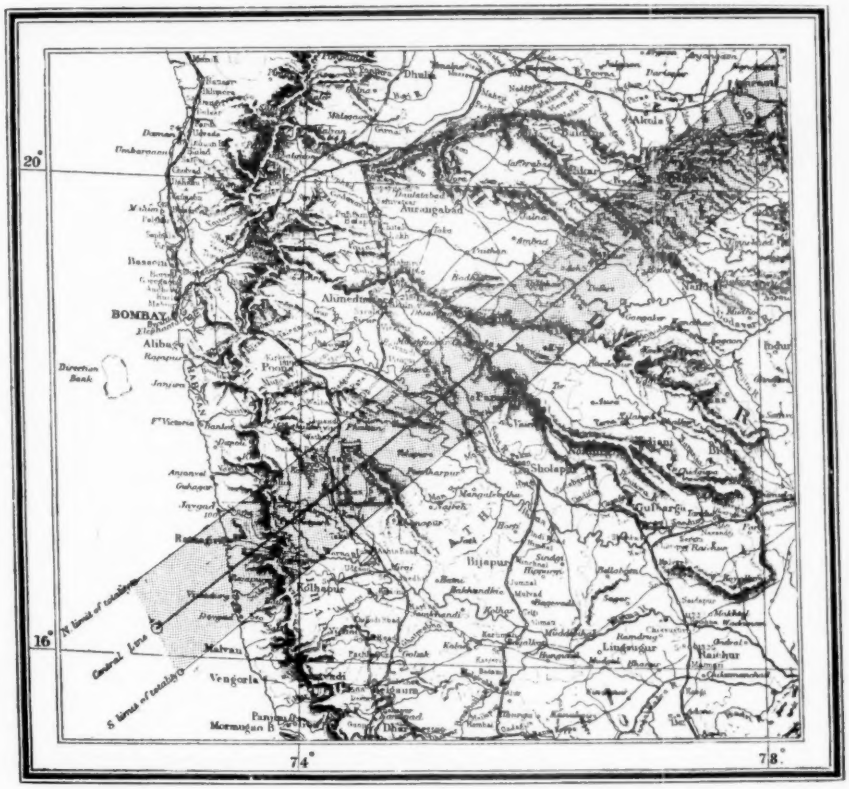
The most favorable stations for observing the eclipse will be found near the east coast of Africa and the western portion of India. So far as the duration of totality and the altitude of the Sun are concerned, there is little choice between these two regions, but the conditions of accessibility and climate all lie in favor of India and it is probable that nearly all the expeditions from other countries will locate themselves along the central line of path of totality across the western portion of Hindostan. Some, in order to distribute the observations over a greater area, and thus lessen the chances of defeat by clouds, as well as to give opportunity for the study of changes in the solar surroundings during the intervals while the shadow travels from point to point, may locate in Africa and in the interior of China. Most amateurs undoubtedly will prefer those points which are accessible by modern means of conveyance in India.

Fortunately the probabilities of clear weather, in the portion of western India crossed by the shadow, are very high in January, so that we have in the case of this eclipse a rare combination of favorable conditions. Recent numbers of *Nature* contain a series of articles on the eclipse by Professor Lockyer,* in the first of which he discusses the weather probabilities. He says "the failure of so many of the eclipse parties last year to secure observations, makes it a matter of congratulation that the weather prospects of the eclipse to be observed in India on January 22 next year seem to be as favorable as they possibly can be." After quoting from a note on the Indian climate, drawn up by Mr. Eliot, F. R. S., Meteorological Reporter to the Government of India, he adds: "It follows from this sketch that the eclipse will occur in the middle of the cold weather and at the most favorable time for travelling in India. Light northeast winds, fine weather, and smooth sea are to be expected. Cyclonic storms are of exceedingly rare occurrence in either sea during the month, and the chances of a gale or of stormy weather in the month, off the

* The approaching total eclipse of the Sun. J. Norman Lockyer. F. R. S. Nature. I June 17; II. June 24; III. Aug. 5, 1897.

coast of the Konkan (from Bombay to Karwar) is, according to Mr. Eliot, less than 1·50."

"Mr. Eliot points out that since the air is very dry over the interior, and the mean daily humidity percentage at stations in the Deccan, Central Provinces, and Berar average about 40°, any




THE CENTRAL LINE OF ECLIPSE IN WESTERN INDIA JANUARY 22, 1898.

instruments brought out from Europe, such as photographic cameras, etc., should be constructed to withstand the action of this great dryness of the air. With regard to cloud, the data show that the coast districts between Karwar and Ratnagiri (which includes the line of totality) is, on the mean of the month, more free from clouds than any other part of the line of totality.'

The accompanying map, taken from Professor Lockyer's paper shows the places located in the path of totality across western India. Three cities near the coast are well within the

shadow, Ratnagiri, Rajapur, and Viziadurg. For Rajapur the following data have been issued by the Nautical Almanac Office:

Rajapur.....Longitude 73° 35′ E., Latitude 16° 40′ N.

| | | | Contact from N. Point | Vertex | Sun's Altitude |
|---|---|---|---|---|---|
| Eclipse begins January | 21, | 23h 13m 58s | 121° W | 100° W | 52° |
| Totality begins | 22, | 0 47 42 | Duration 2m 1.9s | | 53 |
| Totality ends | 22, | 0 49 44 | | | |
| Eclipse ends | 22, | 2 15 51 | 55° E. | 13° E. | 44 |

"The joint committee of the Royal and Royal Astronomical Societies have determined to send out three parties to observe, one on the coast and two inland, at stations to be subsequently decided upon. It has been arranged that the party from the Solar Physics Observatory will occupy the coast station, if the Admiralty can grant the use of a man-of-war to allow an attempt to be made to repeat the *Volage* program of 1896. In this case the station will possibly be the old fort at Viziadurg."

"The land parties—which will include the Astronomer Royal, Professor Turner and Mr. Newall, representing the Observatories of Greenwich, Oxford and Cambridge, together with Dr. Common and Captain Hills—will occupy stations near the central line on the railways shown on the map."

Professor Lockyer gives no account of the work to be done by the parties, except that he himself will use a prismatic camera of large size, hoping to obtain spectrographic evidence of the constitution of the solar atmosphere. Similar apparatus was used very successfully in 1893, by Mr. Fowler in west Africa. Professor Lockyer expects next year to employ apparatus having double the dispersive power of that used in 1893.

Of the American Observatories none have, so far, reported their intention to send out expeditions excepting the Lick Observatory. Professor Campbell will go to India in October of this year. "The program of the expedition will be both spectroscopic and photographic. The principal subjects of observation will be:—

1. Photographs of the spectrum of the reversing layer.
2. Spectrum photographs, to determine the velocity of rotation of the corona.
3. Observation 1 repeated with a different instrument.
4. Photographs of the spectrum of the corona.
5. Photographs of the corona on a large scale (40 foot lens) on the plan first employed by Professor Schaeberle in Chili.
6. Photographs of the corona with a portrait lens, on 8x10 plates.
7. Photographic photometry of the corona, as in the Lick Observatory expeditions of January and December 1889, April 1893, (August 1896)."

## ASTRONOMY IN OUR UNIVERSITIES AND COLLEGES.

G. D. SWEZEY.

FOR POPULAR ASTRONOMY.

The writer had occasion recently to inquire how extensively astronomy, in its various phases, is taught in our universities and colleges, and how generally it is elected by students. It is possible that the results of this inquiry may be of interest to others also.

The facts elicited by a circular letter sent out to a considerable number of institutions are set forth in the following table. The first column shows the whole number of students in the institution during the past year, exclusive of those in law, medicine, and similar technical courses; the second and third columns show the number of undergraduates taking some kind of work in astronomy as required and as elective work respectively; and the fourth column gives the number of graduate students pursuing the study.

It should be said that in some cases the numbers reported were stated to be only approximate, and in one case, where astronomy has this year been omitted from the list of courses offered, the numbers given are those from the preceeding year.

| Institution. | Whole Number of Students. | Undergraduates Taking Astronomy. Required | Elective. | Graduate Students in Astronomy. |
|---|---|---|---|---|
| University of California | 1336 | 12 | 44 | 3 |
| University of Illinois | 1062 | 38 | 38 | 3 |
| University of Michigan | 1550 | 25 | 57 | 6 |
| University of Minnesota | 700 | 0 | 37 | 9 |
| University of Nebraska | 850 | 0 | 36 | 2 |
| University of Pennsylvania | 583 | (thirty in all) | | |
| University of Virginia | 286 | 0 | 13 | 5 |
| University of Wisconsin | 1025 | 15 | 13 | 4 |
| Amherst College | 450 | 0 | 105 | 0 |
| Beloit College | 196 | 9 | 10 | 0 |
| Boston University | 425 | 0 | 38 to 43 | 0 |
| Bowdoin College | 250 | 0 | 48 | 0 |
| Brown University | 908 | 3 | 24 | 2 |
| Carleton College | 265 | (ten to twenty in all) | | |
| Chicago University | 1500 | 0 | 15 | 46 |
| Cincinnati University | 359 | (twenty-four in all) | | |
| Columbia University | 936 | 43 | 10 | 6 |
| Cornell University | 1450 | — | 25 to 40 | 2 to 3 |
| Dartmouth College | 600 | 75 to 95 | 7 to 19 | 1 |
| Denver University | 150 | 0 | 17 | 0 |
| Doane College | 98 | 7 | 0 | 0 |
| Hamilton College | 147 | 0 | 27 | 0 |
| Harvard College | 2417 | 0 | 67 | – |
| Haverford College | 109 | 0 | 3 | 1 |
| Johns Hopkins University | 500 | 0 | 10 | 17 |
| Lawrence College | 111 | 14 | 8 | 0 |
| Lehigh University | 344 | 23 | 0 | 1 |

| Institution. | Whole Number of Students. | Undergraduates Taking Astronomy. Required | Elective. | Graduate Students in Astronomy. |
|---|---|---|---|---|
| Leland Stanford Jr. University | 1100 | 0 | 35 | 0 |
| Mt. Holyoke College | 330 | 44 | 17 | 0 |
| Princeton College | 1045 | 31 | 211 | 1 |
| Purdue University | 650 | 20 | 0 | 0 |
| Rutgers College | 168 | 34 | 0 | 1 |
| Vanderbilt University | 233 | 0 | 20 | 0 |
| Washington University | 170 | 8 | 2 | 0 |
| Yale University | 2000 | 76 | 9 | 0 |

It will appear from an examination of the above table that in only a little more than half of these institutions is astronomy a required study in any of the courses and that the number of students taking astronomy in this way amounts to about 6.2 per cent. of the whole number of students in these institutions or to about 3.5 per cent. of the whole number of students in all the institutions. In a considerable number of cases astronomy is required only of students in engineering courses, with a view to giving them an acquaintance particularly with field methods of determining time, latitude, azimuth and the like.

The number of students taking astronomy as an elective is, on the average, about six per cent of the whole number, and the number in graduate courses about one half of one per cent.

It is of interest to inquire how astronomy fares in those cases where it is wholly elective as compared with those in which it forms part of the required work. In the former case the percentage of students electing the study, averages 9.1; in those institutions where it is a required study the percentage is but slightly greater, being 6.2 per cent. in regular classes and 3.6 per cent. in elective work; it should be noted also that this total of 9.8 per cent. doubtless represents a considerable number of names counted twice, so that it is probable that the actual number of students engaged in the study of astronomy is no greater, if indeed it be not less in those institutions where the study is required, than in those where it is wholly elective. Does this mean that the average American student is bound to study what he pleases? Does it signify that astronomy is so difficult a study to present in a substantial way and at the same time to make it interesting to the beginner that, as a rule, having taken what he must he prefers to pursue the subject no farther?

It is hardly necessary for the writer to undertake any comparison of the work of different institutions in astronomy as the table will enable the reader to do that for himself. It will be seen that there is a wide divergence in the percentages as well as in the actual number of students who take astronomy. The larger per-

centages are found in the smaller institutions, partly no doubt because there are less subjects offered from which to choose than in the larger institutions with many departments, and partly it may be because less time and attention is given to research work in these cases and more to instruction. Yet there are some notable exceptions, as at Princeton College where twenty-one per cent. of the students elect astronomy or three times as great a proportion as in any other of the larger institutions. More specifically the number electing astronomy in institutions numbering more than one thousand students averages about four per cent. of the whole; in those of five hundred to one thousand students the percentage is about three, while in the smaller institutions the number averages about nine per cent.

The amount of graduate work on the other hand is relatively largest in institutions of medium size, averaging in these cases about three-quarters of one per cent. while in the larger institutions it is about one-half, and in the smaller about one-fourth of one per cent.

THE UNIVERSITY OF NEBRASKA, LINCOLN.

## THE TWILIGHT.

ORRIN E. HARMON.

FOR POPULAR ASTRONOMY.

Broadly speaking, the reign of the shortest twilight extends from the time of the equinoxes to the time when the Sun reaches the declination correlative to declination zero. The minimum twilight (given in table IV* as the "shortest twilight") falls very nearly midway between the time of the equinoxes and the time of the Sun's correlative declination.

For latitude 40°, the Sun's declination correlative to zero is 11° 45′ 15″ south. At this declination the twilight duration is the same as at the equinoxes, $1^h\ 35^m\ 10^s$. The minimum twilight is $1^h\ 34^m\ 16^s$, found with declination 5° 50′ 36″ south. This declination is about one-half the correlative declination above given. In fact, if $\delta$ = declination at minimum twilight, and $\delta'$ = declination correlative to zero, then $\delta' = 2\delta$, very nearly.

The near equality of the equinoctial and minimum twilight is noticeable, and is explained as follows: If $T$ = twilight duration at equinoxes, then by formula (7), $\sin T = \frac{\sin 18^\circ}{\cos \varphi}$; and if $t =$

* See POPULAR ASTRONOMY, November, 1896.

minimum twilight duration, then by formula (12) $\sin\frac{1}{2}t=\frac{\sin 9^\circ}{\cos\varphi}$. Dividing (7) by (12) we obtain

$$\frac{\sin T}{\sin\frac{1}{2}t}=\frac{\sin 18^\circ}{\sin 9^\circ}=\frac{.309017}{.156434}=2 \text{ nearly.}$$

Since the sines of the arcs have a constant relation to each other, the arcs themselves will, approximately, have the same relation, when less than 45°. That is $\frac{T}{\frac{t}{2}}=2$, or $T=t$ nearly.

Above latitude 60°, the difference between the equinoctial and minimum twilights rapidly increases; and at latitude 72° the difference is nearly two hours. For instance, the equinoctial twilight at latitude 72° is 6 hours, and the minimum twilight is $4^h\ 3^m\ 18^s$. This duration is produced by declination 8° 39′ 50″ south; while the correlative declination for zero is 17° 58′ 36″ south.

I shall now consider other prominent peculiarities shown by the twilight tables. Referring to table IV on the shortest twilight it will be seen that the change in the Sun's amplitude during twilight is twice the Sun's amplitude, either at the twilight limit or at sunrise. The cause of this relation is explained as follows: Let $Am$ = Sun's amplitude when 18° below horizon. Then we have

$$\sin Am=\frac{\sin\delta-\sin\varphi\sin 18^\circ}{\cos\varphi\cos 18^\circ}.$$

But at the minimum twilight $\sin\delta=\sin\varphi\tan 9^\circ$. Substituting this value of $\sin\delta$, we have

$$\sin Am=\frac{\sin\varphi\tan 9^\circ-\sin\varphi\sin 18^\circ}{\cos\varphi\cos 18^\circ};$$

and remembering that $\sin 18^\circ=2\sin 9^\circ\cos 9^\circ$, and $\cos 18^\circ=2\cos^2 9^\circ-1$, the above equation is reduced to the form of

$$\sin Am=\frac{\tan\varphi\tan 9^\circ(1-2\cos^2 9^\circ)}{2\cos^2 9^\circ-1}=-\tan\varphi\tan 9^\circ \quad (21)$$

Also let $am$ = Sun's amplitude when in the horizon. Then $\sin am=\frac{\sin\delta}{\cos\varphi}$. Substituting value of $\sin\delta$ as before, we have

$$\sin am=\frac{\sin\varphi\tan 9^\circ}{\cos\varphi}=\tan\varphi\tan 9^\circ,$$

the same result given above only with opposite sign.

In each case 9° must be taken negatively. Then for the twilight limit we have sin $Am = \tan \varphi \tan 9°$; and for sunrise, sin $am = -\tan \varphi \tan 9°$. This is why the change of amplitude during minimum twilight is twice the amplitude either at the twilight limit, or at sunrise.

The Sun not only moves an equal distance in amplitude each side of the Prime Vertical during minimum twilight, but he always crosses the Prime Vertical at a constant depression below the horizon. When we know the declination of a heavenly body, and the latitude of the place, we can compute the altitude at which the body crosses the Prime Vertical by the formula $\sin h = \frac{\sin \delta}{\sin \varphi}$, where $h$ = altitude. But at minimum twilight $\sin \delta = \sin \varphi \tan 9°$. Substituting value of sin $\delta$, the above equation becomes $\sin h = \tan 9°$. Since $\delta$ is south or negative, sin $\delta$ is negative. That is $h$ is negative, which shows that the Sun crosses the Prime Vertical below the horizon. Taking the above formula $\sin h = \tan 9°$, we obtain log tan 9° = 9.199713. Wherefore log sin $h$ = 9.199713, and $h = 9° 6' 47''$; and this is the constant depression below the horizon at which the Sun crosses the Prime Vertical at shortest twilight.

We have seen that the Prime Vertical bisects the arc of the Sun's change of amplitude at minimum twilight. Also that he crosses the Prime Vertical at a constant depression at this time. We may now properly ask, Does the Sun, at minimum twilight, cross the Prime Vertical at the middle of the twilight?

Formula (6) gives us $2 \cos \varphi \cos \delta \sin \frac{1}{2}(A + B) \sin \frac{1}{2}(A - B) = \sin m = \sin 18°$. But $\sin \frac{1}{2}(A - B) = \sin \frac{1}{2} t$; and at minimum twilight $\sin \frac{1}{2} t = \frac{\sin 9°}{\cos \varphi}$. Substituting this value of $\sin \frac{1}{2} t$ in (6), we obtain, after reducing,

$$\cos \delta \sin \frac{1}{2}(A + B) = \cos 9° \qquad (22)$$

Now at the middle of the twilight, the Sun's hour angle is $\frac{1}{2}(A + B)$; and if we denote this hour angle by $P$, the Sun's amplitude by $A'm$, and the Sun's zenith distance by $Z$, we have sin $Z$ : cos $\delta$ :: sin $P$ : cos $A'm$. But at minimum twilight, $\sin P = \frac{\cos 9°}{\cos \delta}$. Substituting this value of sin $P$ and remembering $Z > 90°$, we have by reduction

$$\cos d \cos A'm = \cos 9^\circ, \qquad (23)$$

where $d$ = Sun's depression which is $Z - 90^\circ$. Formula (23) shows that *at the middle of minimum twilight, the Sun is always 9° from the east point of the horizon, measured on the arc of a great circle.*

Now if the Sun is on the Prime Vertical at the middle of minimum twilight, then $A'm = 0$, and $\cos A'm = 1$. Wherefore $\cos d = \cos 9^\circ$, or $d = 9^\circ$. But we have already shown that the Sun at minimum twilight crosses the Prime Vertical at the constant depression of 9° 6′ 47″. *Hence the Sun is not on the Prime Vertical at the middle of minimum twilight.* Since $\cos d \cos A'm = \cos 9^\circ$, and since $A'm$ at middle of minimum twilight is greater than zero, $\cos A'm$ must be less than 1. But $\cos d = \dfrac{\cos 9^\circ}{\cos A'm}$. Therefore $\cos d$ is greater than $\cos 9^\circ$, and $d$ is less than 9°, except when the Sun is on the Prime Vertical at middle of minimum twilight. This can happen only at the equator, at the time of the equinoxes. Then $A'm = 0$, and $d = 9^\circ$.

The value of $d$ ranges from 9° at the equator to 8° 53′ 18″ at latitude 81° where the shortest twilight ceases to have any practical value.

It is an easy conclusion from the foregoing reasoning that at minimum twilight, the Sun crosses the Prime Vertical a short time before the middle of the twilight.

Now let us turn to table V (when the middle of the twilight is six o'clock) and notice some of the peculiar features exhibited in that table.

It will be observed that the Sun's amplitude at the twilight limit is negative for all latitudes below 45°.

At latitude 45° the amplitude is zero, and above this latitude the amplitude is positive. It will also be noticed that the amplitude for latitude $45^\circ + a$ is the same as for $45^\circ - a$, differing only in sign.

Applying the change in amplitude during twilight, it will be seen further, that the Sun's amplitude at sunrise is the same for $45^\circ + a$, as for $45^\circ - a$, and that in each case the sign is the same. I will show why this is.

We have found that when the Sun is in the horizon we have $\sin am = \dfrac{\sin \delta}{\cos \varphi}$. But when the middle of the twilight is six o'clock, $\sin \delta = \dfrac{\sin 18^\circ}{2 \sin \varphi}$. Substituting this value of $\sin \delta$, we obtain

$$\sin am = \frac{\sin 18^\circ}{2 \sin \varphi \cos \varphi} = \frac{\sin 18^\circ}{\sin 2\varphi}.$$

Now suppose we have two latitudes, $45^\circ + a$, and $45^\circ - a$. Then $2\varphi = 90^\circ + 2a$ and $90^\circ - 2a$; and since the functions of these angles is the same as the functions of their supplements, we have $\sin (90^\circ + 2a) = \sin (180^\circ - 90^\circ - 2a) = \sin (90^\circ - 2a)$. Similar consideration gives $\sin (90^\circ - 2a) = \sin (90^\circ + 2a)$.

In the formula $\sin am = \frac{\sin 18^\circ}{\sin 2\varphi}$, $\sin 18^\circ$ is negative; and since $\sin 2\varphi$ is always positive, it follows that $\sin am$ will always be negative, and will have the same numerical value for latitude $45^\circ + a$ and $45^\circ - a$. When the Sun is at the twilight limit, we have the formula,

$$\sin Am = \frac{\sin \delta - \sin \varphi \sin 18^\circ}{\cos \varphi \cos 18^\circ}.$$

In this formula again substitute the value of $\sin \delta$, when the middle of the twilight is six o'clock, and we obtain

$$\sin Am = \frac{\tan 18^\circ (1 - 2 \sin^2 \varphi)}{\sin 2\varphi},$$

after making the necessary transformations and reductions.

In the last equation substitute $\sin^2\varphi + \cos^2\varphi$ for 1. Then we have

$$\sin Am = \frac{\tan 18^\circ (\cos^2\varphi - \sin^2\varphi)}{\sin 2\varphi}$$

$$= \frac{\tan 18^\circ \cos 2\varphi}{\sin 2\varphi} = \frac{\tan 18^\circ}{\tan 2\varphi}.$$

The reasoning above given for latitude $45^\circ + a$ and $45^\circ - a$ will apply in the last equation, except there will be a difference in the resulting signs. Tan $18^\circ$ is negative because $18^\circ$ is negative.

When $\varphi = 45^\circ - a$, $2\varphi < 90^\circ$, and $\tan 2\varphi$ is positive.
When $\varphi = 45^\circ + a$, $2\varphi > 90^\circ$, and $\tan 2\varphi$ is negative.

Hence for latitudes below $45^\circ$, $\sin Am$ is negative, and the Sun's amplitude at the twilight limit is south. For latitudes above $45^\circ$, $\sin Am$ is positive, and the Sun's amplitude at the twilight limit is north. This explains the singular law of amplitudes shown in table V, when the middle of the twilight is six o'clock.

Again, in the last case, the Sun exhibits a peculiar feature in this; that when he is on the six o'clock hour circle, his depression below the horizon is constant for all latitudes.

If $d$ = Sun's depression, then $\sin d = \sin \delta \sin \varphi$ (that is when the Sun is on the six o'clock hour circle). But when the middle of the twilight is six o'clock $\sin \delta = \frac{\sin 18^\circ}{2 \sin \varphi}$. Substituting this value of $\sin \delta$, the above equation becomes

$$\sin d = \frac{\sin 18^\circ}{2} = 9.188952 \text{ (log)}.$$

Wherefore $d = 8^\circ\ 53'\ 18''$; and this is the constant depression of the Sun below the horizon when the middle of the twilight is six o'clock. It is also the Sun's depression for latitude 81°, at the middle of minimum twilight.

There is also a constant relation existing between the Sun's declination when the twilight is shortest and when the middle of the twilight is six o'clock.

In the latter case $\sin \delta' = \frac{\sin 18^\circ}{2 \sin \varphi}$; and in the former cases $\sin \delta = \sin \varphi \tan 9^\circ$. Multiplying the equations, we have

$$\sin \delta' \sin \delta = \frac{\sin 18^\circ \tan 9^\circ}{2} = \frac{2 \cos 9^\circ \sin 9^\circ \tan 9^\circ}{2} = \sin^2 9^\circ,$$

remembering $\cos 9^\circ \tan 9^\circ = \sin 9^\circ$. Wherefore $\sin \delta' \sin \delta = \sin^2 9^\circ$. That is *the product of the sines of the Sun's declination where twilight is shortest and when the middle of the twilight is six o'clock, is constant.*

There are some interesting features about the Sun's amplitude when the Sun's declination is 18° N. When the Sun is in the horizon, we have $\sin am = \frac{\sin \delta}{\cos \varphi}$. But when $\delta = 18^\circ$, the formula becomes $\sin am = \frac{\sin 18^\circ}{\cos \varphi}$. But this is the formula for the twilight duration at the equinoxes. Therefore the Sun's amplitude in the horizon at declination 18° N. is equal to the twilight duration at the equinoxes.

Formula (4) gave us

$$\cos A = \frac{\cos a - \sin \varphi \sin \delta}{\cos \varphi \sin \delta},$$

where $A$ = Sun's hour angle at twilight limit, and $a = 108^\circ$. But $\cos 108^\circ = \sin 18^\circ$; and when $\delta = 18^\circ$, the formula becomes

$$\cos A = \frac{\sin 18^\circ - \sin \varphi \sin 18^\circ}{\cos \varphi \cos 18^\circ}.$$

Also we have

$$\cos Az = \frac{\sin 18^\circ - \sin \varphi \sin 18^\circ}{\cos \varphi \cos 18^\circ},$$

where $Az$ = Sun's azimuth at the twilight limit.

That is, at declination 18° N, the Sun's azimuth at the twilight limit is the supplement of the Sun's hour angle. For they each have the same value of the cosine, and we know the hour angle is greater than 90°, and the azimuth is less than 90°. The Sun's amplitude is then the complement of the hour angle. For instance at latitude 40°, the hour angle is 134° 10′ 13″, and the Sun's amplitude 44° 10′ 13″. Azimuth = 45° 49′ 47″ which is the supplement of 134° 10′ 13″.

CHEHALIS, Lewis Co., Wash.

## EVENING WITH THE STARS.

MARY PROCTOR.

FOR POPULAR ASTRONOMY.

During the month of September the Great Bear (*Ursa Major*) is low down between northwest and north, the Pointers (*Alpha* and *Beta*), directed slantingly upward toward the Pole. Between the Great Bear and the Little Bear run the stars of the Dragon (*Draco*), round the Little Bear toward the north, thence towards the northwest, where we see the head of the Dragon high up, its two bright eyes, Beta and Gamma, directed toward *Hercules*, which occupies the western mid-heaven. Above Hercules is *Lyra*, the Lyre, with the bright steel-blue star Vega high up toward the point overhead. Right overhead is the Swan (*Cygnus*). Low down in the northwest is the insignificant constellation of the Hunting Dogs (*Canes Venatici*). Nearer the west stands the Herdsman, rather slanting forward, however, with the Crown (*Corona Borealis*) on his left, almost due west. The long winding Serpent (*Serpens*) runs from near the Crown (where we see its head due west) to farther south than southwest, high up on the western side of the Serpent Holder (*Ophiuchus*), now standing upright in the southwest. Low down creeps the Scorpion (*Scorpio*), its heart Antares, rival of Mars, in the southwest, the end of its tail between south and southwest. Above and south of the Scorpion's tail we see the Archer (*Sagittarius*).

Due south, and high up, is the Eagle (*Aquila*), its tail at Zeta and Epsilon, its head at Theta, the bright steel-blue Altair marking its body. On the left, or east, of the Eagle lies the neat little Dolphin (*Delphinus*). Midway between the Dolphin and the horizon is the tip of the tail of the Sea Goat (*Capricornus*), whose head lies nearly due south. In the southeast lies Fomalhaut, the chief brilliant of the Southern Fish (*Piscis Australis*). Above is the Water-Bearer (*Aquarius*), in the southwestern mid-heaven. Due east, fairly high, is "the square of Pegasus," the head of the Winged Horse, Pegasus being between the Water-Bearer and Andromeda. In fact (*Alpha*) in Andromeda, is one of the stars forming "the square of Pegasus."

The Fishes (*Pisces*) are low down in the east. A few stars of the Whale (*Cetus*) are seen on their right, very low down. On the left of Pisces we see the

Ram (*Aries*), low down; above it the Triangle, and above that the Chained Lady (Andromeda). Low down in the northeast is the Rescuer (*Perseus*), near by is (*Cassiopeia*), and on her left, higher up, is the constellation *Cepheus*. Immediately below Cepheus, we find the Camelopard, below which, very low down, between north and northeast, is the Charioteer (*Auriga*), the brilliant Capella being just above the horizon.

The constellations occupy these positions on September 6th, at 9 o'clock; September 14th at 8:30 o'clock, and on September 21st at 8 o'clock.

### Constellation of Cygnus.

The constellation of Cygnus, the Swan, is situated in the Milky Way, and in olden maps, it is represented as a swan with outspread wings, flying down the Milky Way towards the southwest. The constellation is sometimes known by the name of the Northern Cross, the cross-piece extending from *Delta* to *Epsilon*, and the upright piece from *Alpha* to *Beta*. It lies immersed in one of the richest regions of the Milky Way, but in contrast to this wealth of stars is a dark rift in their near neighborhood. "Between the stars Alpha, Gamma, and Epsilon, is the strange dark gap in the Galaxy, called the Coal-Sack, a sort of hole in the starry heavens. Although it is not entirely void of stars, its blackness is striking in contrast with the brilliancy of the Milky Way in its neighborhood. The divergent streams of the great river of light in this region, presents a very remarkable appearance."*

### Legends of the Swan.

According to Ovid, this constellation took its name from Cygnus, a relative of Phaeton, who deeply lamented the untimely fate of that youth, and the melancholy end of his sisters, who standing around his tomb, they wept themselves into poplars.

### Albireo (*Beta Cygni*)

*Albireo*, (R. A. $19^h$ $26^m$., Decl. $+ 27° 42'$) is one of the finest colored double stars in the sky when seen with a small telescope. A magnifying power of 10 diameters splits it with ease. With a larger telescope, the contrasting colors are finely seen, the primary being a yellow star of the third magnitude, the component being a blue star of the fifth magnitude, distance 34″. The primary is variable, but the variations of brightness are not important, the color also varies slightly.

### Deneb (*Alpha Cygni*)

Deneb, R. A. $20^h$ $37^m$; Decl., $+ 44° 53.2'$. It is a star of the first magnitude, 24° N. E. of Lyra, and 30° north of the Dolphin. It is the most brilliant star in the constellation, and of the first magnitude. It is situated at the upper end of the cross, and comes to the meridian at 9 o'clock, on the 16th of September. It has a distant companion star of the 12th magnitude, which however cannot be seen with a small telescope.

### Nova Cygni.

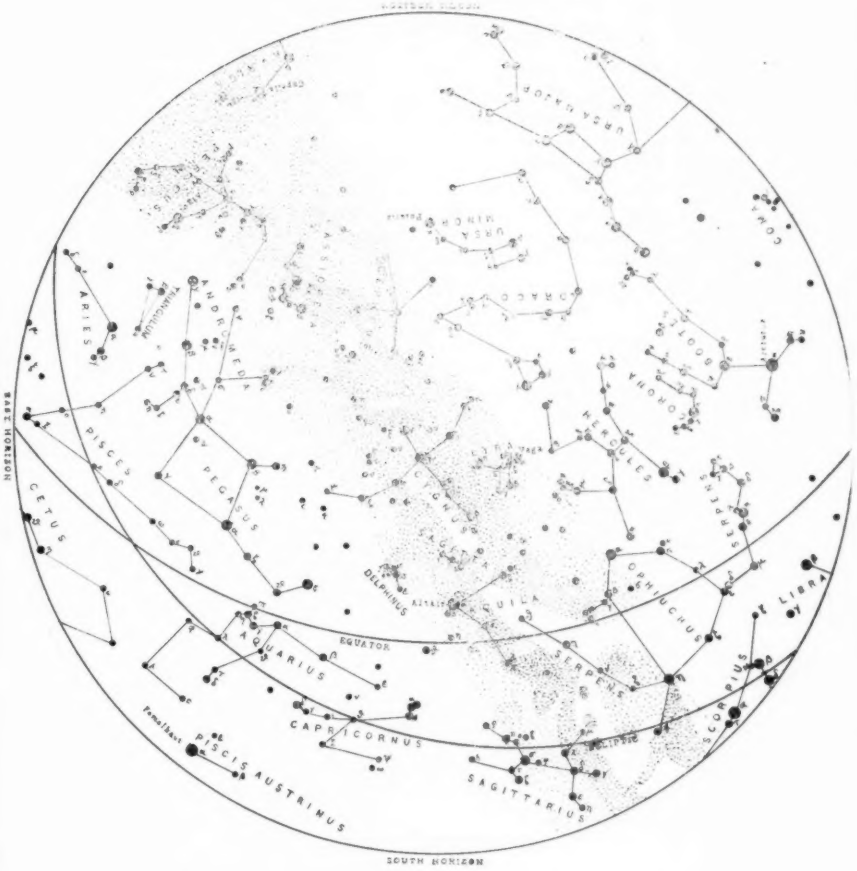
*Nova Cygni*. R. A. $21^h$ $37^m$, Decl. $+ 42° 18'$ was discovered November 24th, 1876, by Schmidt. It is a yellow star of the third magnitude. It was at once apparent that a decrease of brilliancy was taking place, and in September 1877, the star was only 20 5 magnitude; in the following year it was only 13–14 magnitude, and invisible except in the most powerful telescopes.

### 61 Cygni.

*61 Cygni* is a star of the fifth magnitude with a companion of the sixth mag-

* Astronomy with an opera glass, p 57. Garrett P. Serviss.

nitude, both golden yellow in color, but slightly differing in tint. The distance is 20″, and the change of position is rapid, it has not yet been possible, however, to calculate the period of revolution. It has been reckoned to be approximately 783 years. To locate 61 Cygni, draw a line between Sigma and Epsilon, and 61 is nearly half-way between, being nearer Sigma than Epsilon.*




THE CONSTELLATIONS AT 9 P. M., SEPTEMBER 1, 1897.

Agnes M. Clerke writes about it as follows: "The stars of 61 Cygni share a rapid onward movement through space. They are among our nearest stellar neighbors, and there is nearly the same amount of inequality between them. Although they have been under continuous scrutiny since 1753, when Bradley noted

* It is marked on Map 12, in "*Astronomy with an Opera Glass*," p. 56.

the difference in their times of transit, it is only within the last few years that the curvature of their path has become perceptible. While marching alongside of it, with what is called a "common proper movement," the smaller also shifts its place sensibly as regards the larger star. But for a century and upward, the shifting appeared to take place along a straight line. If this had really been the case, the fact would have abolished the presumption of their primary character, and compelled the belief, which was actually adopted by Captain Jacob in 1858, that the stars would eventually part company and cease to have an apparent connection. It is now, however, evident that they have not the slightest intention of doing so. The first symptoms of a bend in their track were noticed by Mr. Wilson in 1875; and Dr. C. F. W. Peters' investigations in 1885, not only showed them to be revolving, but set forth, at least provisionally, the circumstances of their revolution. In a period of 783 years the companion-star describes round its primary (supposed for the purpose of calculation to be at rest) an orbit of larger angular or apparent dimensions than those assigned to any other stellar path. Its mean radius measures 29½", and this at the distance of 61 Cygni (about forty billion miles), is equivalent to an interval just 65½ times that between the Earth and Sun. These stars then circulate in an orbit more than twice as wide as that of the planet Neptune, and nearly as eccentric as that of the planet Mercury.*

### Nearest Star in the Northern Hemisphere.

*61 Cygni* was the first star, whose distance was determined, and this was accomplished in 1838, by the illustrious Bessel of Königsberg. He ascertained its parallax to be about a third of a second. However this turned out to be slightly too small, and was augmented to 0" 42 by Auwers' re-discussion in 1868 of the same date.† The two most reliable determinations are, perhaps, Sir Robert Ball's in 1879, giving a value of 0".465, and Professor Pritchard s, giving 0".432 from photographic comparisons in 1887.‡

### Constellation of Capricornus, the Goat.

If a line be drawn from Lyra through Altair, and produced about 23° farther, it will point out the head of Capricorn, and pass very close to *Alpha* and *Beta*. These stars come to the meridian the 9th of September. Its mean declination is 20° south, and its mean right ascension, 310°. It is therefore on the meridian about the 18th of September. The whole number of stars in this constellation is 154, none of which are very conspicuous. The three largest, are of the third magnitude, and there are three of the fourth.

Capricornus is said to be Bacchus, who, with some other deities were feasting upon the banks of the Nile, when suddenly the dreadful giant Typhon came upon them, and compelled them all to assume a different shape, in order to escape his fury. Bacchus assumed the form of a goat.

### Telescopic Objects of Interest.

*Alpha Capricorni*, R. A. $20^h\ 11^m$, Decl. $-12°\ 55'$, is a double double-star. It has two stars of the third and fourth magnitude, both yellowish, and at a distance of 376" from each other. Each of them is itself double.

In writing about *Alpha* Serviss refers to it as follows: "A keen eye will readily perceive that *Alpha* really consists of two stars. They are about six minutes of arc apart, and are of the third and the fourth magnitude respectively. These

* *System of the Stars*, p. 169. Agnes M. Clerke.
† *Astr. Nach.* No. 385.
‡ *System of the Stars*, p. 303. Agnes M. Clerke.

stars, which to the naked eye appear almost blended into one, really have no physical connection with each other, and are slowly drifting apart. The ancient astronomers make no mention of Giedi (*Alpha*) being composed of two stars, and the reason is plain, when it is known that in the time of Hipparchus, as Flammarion has pointed out, their distance apart was not more than two-thirds as great as it is at present, so that the naked eye could not have detected that there were two of them; and it was not until the seventeenth century that they got far enough asunder to begin to be separated by eyes of unusual power. With an ordinary opera-glass they are thrown well apart, and present a very pretty sight. Considering the manner in which these stars are separating, the fact that both of them have several faint companions, which our powerful telescopes reveal, becomes all the more interesting. A suggestion of Sir John Herschel, concerning one of these faint companions, that it shines by reflected light, adds to the interest, for if the suggestion is well founded the little star must, of course, actually be a planet, and granting that—then some of the other faint points of light seen there are probably planets too. It must be said that the probabilities are against Herschel's suggestion. The faint stars more likely shine with their own light. Even so, however, these two systems, which apparently have met and are passing one another, at a distance small as compared with the space that separates them from us, possess a peculiar interest, like two celestial fleets that have spoken to one another in the midst of the ocean of space."*

*Beta Capricorni*, is a double star R. A. $20^h\ 14^m$, Decl. $-15°\ 10'$. It is of the third magnitude and of a golden yellow with a blue companion of the sixth magnitude, at a distance of 205″. "The blue of the small star can be seen with either an opera or a field-glass, but it requires careful looking and a clear and steady atmosphere."

## PLANET NOTES FOR SEPTEMBER.

H. C. WILSON.

*Mercury*, having passed greatest eastern elongation Aug. 26, is now approaching inferior conjunction, and will reach that position on the morning of Sept. 22, just before the Sun's center crosses the equator. Mercury will then be a little more than two degrees south of the line joining the Earth and Sun's centers. On the 27th Mercury, being then a morning planet will be in conjunction with Jupiter, passing the latter in retrograde motion.

*Venus* as "morning star" is waning in brightness, being less than half as bright as in June. She is to be seen toward the east after two o'clock in the morning. About three-quarters of the disk is now illuminated and this increases to over eight tenths during the month. Venus is beginning to turn southward but is yet at a high altitude when on the meridian, so that this should be a most favorable month for the study of the planet.

*Mars* is too near the Sun for observation, although it may be seen toward the west an hour after sunset.

*Jupiter* will be behind the Sun, at superior conjunction, Sept. 12 at midnight and cannot be observed during this month.

*Saturn* may be seen toward the southwest in the early evening but at too low an altitude for good seeing.

* Astronomy with an Opera Glass, p. 65. Garrett P. Serviss.

*Uranus* is near Saturn and so is in the same unfavorable condition as to observation.

*Neptune* will be at quadrature, 90° west from the Sun, Sept. 14. Neptune's position Sept. 1 will be: Right ascension $5^h\ 27^m\ 16^s$; Declination north 21° 53′, this is about a degree northwest of the third magnitude star ζ Tauri, in the horn of Bull. Neptune's motion will be exceedingly slow in September, first toward the east then back toward the west upon almost the same line among the stars, so that it will be quite difficult to recognize the planet by its motion.

## The Moon.

| | Phases. | Rises. (Local Time.) | Sets. |
|---|---|---|---|
| | | h m | h m |
| Sept. 3 | First Quarter | 1 34 P. M. | 9 55 P. M. |
| 10 | Full Moon | 5 55 " | 6 13 A. M. |
| 18 | Last Quarter | 9 53 " | 2 23 " |
| 26 | New Moon | 6 2 A. M. | 5 30 P. M. |

## Occultations Visible at Washington.

| Date 1897. | Star's Name. | Magnitude. | IMMERSION. Washington M. T. h m | IMMERSION. Angle f'm N pt. ° | EMERSION. Washington M. T. h m | EMERSION. Angle f'm N pt. ° | Duration. h m |
|---|---|---|---|---|---|---|---|
| Sept. 2 | *b* Scorpii* | 5.3 | 10 28 | 100 | 11 23 | 264 | 0 55 |
| 4 | 3 Sagittarii | 4 6 | 5 18 | 135 | 6 17 | 226 | 0 59 |
| 18 | 139 Tauri | 5.3 | 11 17 | 100 | 12 12 | 248 | 0 55 |
| 19 | ω Geminorum | 5 7 | 17 25 | 150 | 18 27 | 234 | 1 2 |

* Whole occultation below the horizon of Washington.

**Solar Eclipse, July 29, Marengo, Ill.**—The partial solar eclipse was observed at Marengo with the six and a half inch reflector, aperture reduced to three and a half inches. The air was clear and unusually steady. The clock correction was obtained from transits taken during the eclipse. The times were:

First contact, $7^h\ 40^m\ 24.2^s$, 4 or 5 seconds late,
Last " 9 51 25.0 good.

The times are local mean time, and the position of the Observatory is:

Long. $5^h\ 54^m\ 25.18^s$; Lat. + 42° 14′ 51.″5; Alt. 850 ft.

J. A. PARKHURST.

**Eclipse of the Sun July 29 at Alta, Ia.**—The partial eclipse of the Sun which occurred on July 29th ult. was observed here in a perfectly clear sky.

First contact was noted at $7^h\ 33^m\ 02^s$ A. M., the Sun's disc was a little unsteady and this time may be a few seconds in error. The last contact was quite accurately observed at $9^h\ 35^m\ 47^s$.

At $7^h\ 47^m\ 20^s$ the limb of the advancing Moon bisected the larger sun-spot nearest the west limb, its reappearance was noted at $8^h\ 20^m\ 55^s$.

About 4 digits of the disc was obscured, the sunlight was much dimmed about the time of mid-eclipse and the temperature of the air fell 4° in the shade, as recorded by a registering minimum thermometer.

Observations were made with a four-inch Brashear equatorial telescope with Herschelian eyepiece, power 78. The time used is Central Standard, which is $21^m$ faster than mean time.

DAVID E. HADDEN.

Alta, Iowa.

Latitude + 42° 40′
Longitude W $6^h\ 21^m$ } approx.

**Solar Eclipse July 29, Omaha, Neb.**—The solar eclipse of July 29 was observed very successfully at Creighton College Observatory. A five-inch equatorial with driving clock was used, and the enlarged image of the Sun was projected upon a piece of white cardboard attached to the eye-end of the telescope. The image was slightly tremulous. The contacts were observed on a chronograph, and occurred $0^s.43$ and $0^s.92$ after the predicted times $7^h\ 29^m\ 3^s.00$ and $9^h\ 36^m\ 19^s.80$, A. M., Central Time. My brother, Joseph Rigge, noted the contacts about 1½ and 2 seconds before I did, but as he had no observing key this interval could not be determined with accuracy. Good time observations were secured with the transit the night before and after, and also during the eclipse. The Greenwich longitude of our Observatory is $6^h\ 23^m\ 46^s.96$, the latitude 41° 16′ 5″.6, and height above sea level 1154 feet. WM. F. RIGGE, S. J.

**The Partial Solar Eclipse, July 29, 1897.**—At Northfield the beginning of the eclipse was noted by Dr. W. V. Metcalf, Professor of Chemistry and Physics in Carleton College, at $7^h\ 38^m\ 0.7^s$ A. M. Central Standard time. He observed with the 5-inch guiding telescope of the photographic equatorial, power 100, and Mrs. Metcalf noted the time on the chronometer Bond 374. Dr. Metcalf said that shadow was just a little on the solar disk when he noticed it. He thought the time could not be more than a second or two late.

Dr. Wilson observed with the 16-inch telescope and polarizing eyepiece, power 200, and noted times on the chronograph. First contact was lost owing to an erroneous setting of the eyepiece. Last contact was noted very accurately, with good seeing, at $9^h\ 35^m\ 24\ 5^s$ Central Standard time.

The times of occultation of the large sunspot were noted as follows:

| | | | Central Standard time. | | | |
|---|---|---|---|---|---|---|
| Shadow touches | penumbra | of large spot | $7^h$ | $57^m$ | $3\ 5^s$ | A. M. |
| " " | umbra | " " " | 7 | 58 | 22.9 | " |
| " " | bridge | " " " | 7 | 59 | 43.9 | " |
| " leaves | umbra | " " " | 8 | 1 | 21.1 | " |
| " " | penumbra | " " " | 8 | 5 | 38 6 | " |

The last time noted was uncertain owing to an interval of poor seeing.

## VARIABLE STARS.

J. A. PARKHURST.

### Maxima and Minima of Long Period Variables.

1897 November.

| MAXIMA. | | Day | MAXIMA. | | Day | MINIMA. | | Day |
|---|---|---|---|---|---|---|---|---|
| 62 | S Sculptoris | 10: | 5758 | X Herculis | 7: | 2100 | U Orionis | 3: |
| 806 | *o* Ceti (*Mira*) | 9: | 5831 | S Scorpii | 21 | 2625 | V Geminorum | 17 |
| 893 | U Ceti | 9 | 5856 | W Ophiuchi | 6 | 2676 | U Monocerotis | 19 |
| 1717 | V Tauri | 6 | 5950 | W Herculis | 22 | 2976 | V Cancri | 25 |
| 1761 | R Orionis | 17 | 6050 | RS Scorpii | 4: | 5504 | S Coronæ | 12 |
| 2583 | $L_2$ Puppis | 24 | 6331 | RU Scorpii | 30: | 5675 | V Coronæ | 9 |
| 2780 | T Geminorum | 3 | 6624 | T Serpentis | 28 | 5795 | W Scorpii | 29 |
| 3418 | R Carinæ | 11 | 7106 | S Vulpeculæ | 25 | 6794 | R Lyræ | 20 |
| 3425 | X Hydræ | 23 | 7257 | R Sagittæ | 24 | 7085 | RT Cygni | 19 |
| 3994 | S Leonis | 26 | 7456 | RR Cygni | 2: | 7252 | W Capricorni | 16: |
| 4816 | V Virginis | 5 | 7482 | U Pavonis | 15: | 7257 | R Sagittæ | 8 |
| 5430 | T Libræ | 16 | 7754 | W Cygni | 11 | 7779 | S Cephei | 23 |
| 5601 | S Ursæ min. | 10 | 8153 | R Lacertæ | 24 | | | |

## Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time.]

R CANIS MAJ.

1897.

| | d | h |
|---|---|---|
| Oct. | 2 | 13 |
| | 3 | 17 |
| | 4 | 20 |
| | 5 | 23 |
| | 10 | 12 |
| | 11 | 15 |
| | 12 | 19 |
| | 13 | 22 |
| | 18 | 11 |
| | 19 | 14 |
| | 20 | 17 |
| | 21 | 21 |
| | 27 | 13 |
| | 28 | 16 |
| | 29 | 20 |
| | 30 | 23 |

U CORONÆ.

| | | |
|---|---|---|
| Oct. | 12 | 12 |
| | 26 | 8 |

U CEPHEI.

1897.

| | d | h |
|---|---|---|
| Oct. | 1 | 18 |
| | 4 | 6 |
| | 6 | 18 |
| | 11 | 18 |
| | 16 | 17 |
| | 21 | 17 |
| | 26 | 17 |
| | 31 | 16 |

ALGOL.

| | | |
|---|---|---|
| Oct. | 3 | 10 |
| | 6 | 6 |
| | 14 | 21 |
| | 17 | 18 |
| | 20 | 15 |
| | 23 | 11 |
| | 26 | 8 |

S CANCRI.

| | | |
|---|---|---|
| Oct. | 14 | 16 |

λ TAURI.

1897.

| | d | h |
|---|---|---|
| Oct. | 3 | 18 |
| | 7 | 17 |
| | 11 | 16 |
| | 15 | 15 |
| | 19 | 13 |
| | 23 | 12 |
| | 27 | 11 |
| | 31 | 10 |

U OPHIUCHI.

| | | |
|---|---|---|
| Oct. | 2 | 17 |
| | 11 | 2 |
| | 19 | 11 |
| | 27 | 21 |

W DELPHINI.

| | | |
|---|---|---|
| Oct. | 5 | 20 |
| | 10 | 15 |
| | 15 | 10 |
| | 20 | 6 |
| | 29 | 20 |

RS SAGITTARII.

1897.

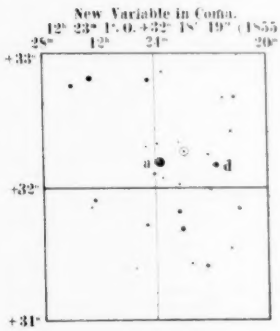
| | d | h |
|---|---|---|
| Oct. | 1 | 8 |
| | 3 | 18 |
| | 8 | 14 |
| | 13 | 10 |
| | 15 | 20 |
| | 20 | 16 |
| | 27 | 22 |
| | 30 | 8 |

Z HERCULIS.

| | | |
|---|---|---|
| Oct. | 2 | 8 |
| | 6 | 8 |
| | 10 | 8 |
| | 14 | 8 |
| | 18 | 8 |
| | 22 | 8 |
| | 26 | 7 |
| | 30 | 7 |

The above ephemeris was computed for POPULAR ASTRONOMY directly from the elements given in Chandler's Third Catalogue, except that for U Cephei the revised elements given in A. J. No. 396 were used. Every tenth minimum of U Ophiuchi is given. The intermediate minima can be interpolated with the period $20^h\ 8^m$.

*Anderson's Latest Variable.* In Astronomische Nachrichten No. 3433 Anderson announces the discovery of a new variable in Coma. Its place as estimated from the D. M. charts, was $12^h\ 23.0^m$, $+32°\ 17'$, for 1855. It is not in the Durchmusterung, but he found it 8.8 magnitude 1897 May 29 and June 8. July 9 and 10 it could not be seen with his 2¼-inch refractor, and so must have been fainter than 9.5 magnitude. I looked for it August 1 and found an 11th magnitude star in its place. Micrometric comparisons with the two neighboring catalogue stars (see chart) $a$ = DM + 32°,2252 = Lalande 23402-3, and $b$ = DM + 32°,2250 = Weisse-Bessel XII$^h$ 460, gave the place of the star




R. A. $12^h\ 23^m\ 1.0^s$, Decl. $+32°\ 18'\ 19''$, (1855)
$25\ 15.2$ $3\ 22$ (1900)

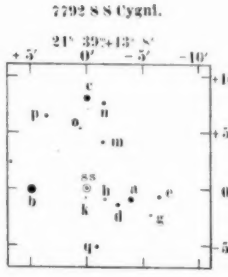
This corresponds sufficiently well with Anderson's estimate, as he says that it may be 1′ in error. Up to the present time, Aug. 16, I have found no certain change in this star, though a slight decline, 0.2 or 0.3 of a magnitude, is suspected; yet this is uncertain, from the low altitude of the star and the bright moon. There is, therefore, only a reasonable presumption that this is the variable, if not it will be found within 1′ or 2′ of the measured place.

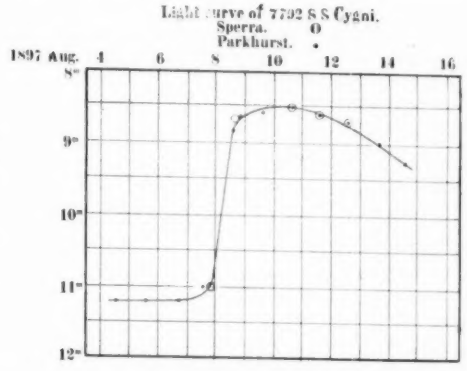
The places of the nearer comparison stars, with their approximate magnitudes, are as follows:

| | Co-or. from V. R. A. s | Decl. ′ | Mag. | | Co-or. from V. R. A. s | Decl. ′ | Mag. |
|---|---|---|---|---|---|---|---|
| *d* | − 67 | − 6.6 | 7.9 | *a* | + 48 | − 4 9 | 7.4 |
| *l* | − 44 | − 2.1 | 12 | *h* | + 58 | + 3.8 | 11 |
| *c* | + 10 | + 4.5 | 11.5 | *e* | + 61 | − 12.2 | 10 |
| *g* | + 11 | − 14.8 | 11 | *k* | + 83 | + 3.1 | 11 |
| *f* | + 43 | − 13.1 | 11 | | | | |

The stars *a* and *d* are lettered on the accompanying chart, from these the places of the others can easily be inferred.

*SS Cygni.* Mr. W. E. Sperra has reduced all the available observations of the June maximum and finds the date to be June 8.83 Greenwich time, at 8.47 magnitude. It was 11.2 magnitude June 2.6 and 8.6 magnitude June 4.6, so that the rise occupied 2 days or less. It had fallen to 11.2 magnitude June 21. It remained at this brightness till Aug. 7. I have 24 observations during this interval, showing no variation greater than 0.1 or 0.2 magnitude. The following observed magnitudes will show the rise and the August maximum. In the column "Observer," S stands for W. E. Sperra, and P for J. A. Parkhurst. The decimals of a day are given in Greenwich Mean Time.




| | Date. | Mag. | Observer. | | Date. | Mag. | Observer. |
|---|---|---|---|---|---|---|---|
| 1897 | Aug. 5.63 | 11.2 | P | Aug. | 10.57 | 8.5 | S |
| | 6.58 | 11.2 | P | | 10.58 | 8.5 | P |
| | 7.64 | 11.0 | P | | 11.58 | 8.6 | S |
| | 7.86 | 11.0 | S | | 11.60 | 8.6 | P |
| | 8.60 | 8.8 | P | | 12.57 | 8.7 | S |
| | 8.63 | 8.65 | S | | 12.58 | 8.7 | P |
| | 8.90 | 8.6 | P | | 13.58 | 9.0 | P |
| | 9.58 | 8.6 | P | | 14.58 | 9.3 | P |

The comparison star *b* was used by both, Mr. Sperra's estimate of its magnitude being 8.4, while mine was 8.5. I have therefore added 0.1 to Mr. Sperra's magnitudes near maximum to reduce to my light scale. The unexpected close agreement between our estimates of the variable shows that the scales, thus corrected, are in substantial accord.

The above observations, when plotted, give the maximum Aug. 10.5 at 8.5

magnitude. The greater part of the rise took place between Aug. 7.86 and 8.60; 2.2 magnitudes in less than 18 hours. The close resemblance of the light curve, here shown, to that of 2815 U Geminorum, will appear by comparison with the curves for the latter star, given in POPULAR ASTRONOMY II, 417 and V, 17. It is too soon to try to find any law for the recurrence of the maxima, the intervals so far recorded being 62, 36, 43 and 63 days.

The accompanying chart shows the nearer comparison stars, and the following list gives their positions and the magnitudes of those which I haved used.

| | Co-or. from V. R. A. | Decl. | Mag. | | Co-or. from V R. A. | Decl. | Mag. |
|---|---|---|---|---|---|---|---|
| | s | ′ | | | s | ′ | |
| *e* | − 35 | − 0.7 | 10.8 | *q* | − 5 | − 5.3 | |
| *g* | − 31 | − 2.4 | 11.2 | *c* | − 0 | + 8.0 | 9.5 |
| *a* | − 21 | − 1.0 | 9.6 | *k* | 0 | − 0.9 | 12.4 |
| *d* | − 15 | − 1.4 | 10.5 | *o* | + 4 | + 5.4 | |
| *h* | − 8 | − 1.1 | 11.9 | *p* | + 20 | + 6.4 | |
| *n* | − 8 | + 7.7 | | *b* | + 27 | − 0.2 | 8.5 |
| *m* | − 6 | + 4.2 | 11.2 | | | | |

The magnitudes are deduced from photometric measures by Pickering and H. M. Parkhurst, and visual estimates by Deichmüller, Sperra and myself. The scale cannot be regarded as definite, but will be revised when more material is available.

Mr. W. E. Sperra undertook to watch for U Geminorum as soon as it became visible in the morning sky. He was rewarded by finding it about 9.5 magnitude Aug. 17.9, Greenwich time. He requested me to verify and I found it about 10.5 magnitude Aug. 20.9. On account of the twilight, the observations were difficult and only suggest a maximum between Aug. 10 and 15. In connection with the June maximum they will be useful in keeping track of the number of the epoch

## GENERAL NOTES.

Those interested in the business part of this publication will find full directions on the last page of this number.

**The Twin Canals of Mars.**—Mr. Percival Lowell's brief article, elsewhere printed, giving measures of some of the double canals of Mars with its accompanying plate will interest all readers. We are sorry that one bad error appears in line twenty-five. The *seventy degrees* should read *seven degrees.*

**August Meteors**—From a private letter received recently from Professor Barnard of the Yerkes Observatory, Lake Geneva, Wis., we gather interesting facts, concerning the meteors of last month. The full Moon interfered with the observation of the August meteors. From this cause, or from a real scarcity of meteors, there were not many of them seen. Mr. Barnard exposed plates with two cameras on the mornings of Aug. 10, 11 and 12 in the hope of catching some trails. The lenses were of the following dimensions:

Lantern lens, 1.5 inches; 6.4 inches focus.

Clark portrait lens, 3.4 inches; 19.4 inches focus. The exposures on the morning of the 11th, both showed a fine meteor trail. The full path of the meteor was recorded on both plates. Near the end of the path the meteor evidently exploded

as there is an enlargement of the trail at that point. The trail shows very beautifully, though off to the edge of the field, it resembles a slender spear of light, and is about 8° long. The Meteor was moving due south from the radiant. The apparent position of the ends of the trail are (from Proctor's smallest Star Atlas for 1880):

Beginning, $\alpha = 2^h\ 59^m,\ +23°$
Ending, $\alpha = 2^h\ 59^m,\ +32°$

**The Rotation of Venus and Mercury.**—I have to thank Dr. See for his replies to my questions. I had no intention of laying down the rotation-periods of Mercury and Venus—in fact I have not formed any opinion on that subject. My question was merely whether *if* they always turned the same face towards the Sun this fact would afford any evidence of an original rotation of either planet distinct from the motion of revolution round its primary. I understand Dr. See to answer this question in the negative, though he thinks from considerations based on the Nebular Theory that there was such a rotation which has been destroyed by tidal action.

As to the instantaneous (or practically instantaneous) propagation of gravity, I am glad to find that Dr. See regards Laplace's proof as unsatisfactory. I should be glad if he could refer me to any computation of the path which a body would describe under the influence of an original projectile force and the attraction of a central body propagated in time—for example if the attraction were that of electricity not gravity. Something of the kind seems to be supposed to occur in the case of comets which are regarded as influenced by the instantaneous attraction of gravity together with a time propagated electric repulsion.

W. H. S. MONCK.

**Professor S. P. Langley in Paris.**—The Secretary of the Smithsonian Institution, Washington, D. C., was at a meeting of the Academy of Sciences in Paris, August 2, said to be the first time in a number of years. The President of the Academy reviewed, at some length, the work of Professor Langley in the department of Physics, and M. Berthelot greeted him in behalf of French aeronauts. Professor Langley, who was very cordially received by the Academy, gave an account of his experimental study of the steam Aeroplane.

**Articles on Tides by Dr. See.**—We are able to announce a series of popular articles on tides by Dr. See, who has given more attention to this subject than any other investigator in this country. The well known defects of the discussions in all our text-books will make this series doubly valuable for the student of astronomy. It is understood that these papers are the outcome of preliminary work which Dr. See is doing on Volume II of his great work on the *Evolution of the Stellar Systems.*

**New Measures of $\beta$ 883.**—Dr. See writes from the Lowell Observatory, Flagstaff, Arizona, under date of Aug. 24: "We recently secured additional measures of $\beta$ 883, and found that the star is following the orbit given in the *Monthly Notices* for June. The mean of measures by Mr. Cogshall and Dr. See is about as follows:

$$\theta = 39°.0 \qquad \rho = 0''.30$$

The companion is now near the end of the apparent orbit, and is moving

slowly; but it ought to be followed regularly with large telescopes, as the motion in about another year will again be rapid."

**Annals of the Observatory of Nice.**—Another splendid volume "Annales de l'Observatoire de Nice Tome VI. M. Perrotin," has just been issued by the "Bureau des Longitudes" of Paris, France. It contains a memoir by M. Simonin on the Orbit of Hecuba, a catalogue of 302 nebulæ discovered by M. Javelle with the 30-inch equatorial, Results of Meridian Observations during 1890, Observations of Transits with the Gautier Circle, 1891-93. The volume contains about 630 quarto pages. The memoir on the orbit of Hecuba is an important one from the fact that this asteroid has a mean motion very nearly double that of Jupiter and is therefore subject to repeated perturbations, of the same character, of its orbit. The planet has been observed at 14 oppositions, between the years 1869 and 1895. M. Simonin has developed new formulæ for the computation of the perturbations when the period is commensurable with that of the disturbing body, and finds that they may be put in comparatively simple form. He gives osculating elements of the planetoid at 25 year intervals during the next 350 years.

**Change of the Constants of Precession, Nutation and Aberration.**—Wm. Harkness, Professor of Mathematics, United States Naval Observatory and Director of the Nautical Almanac, has recently issued a circular to astronomers in regard to the values of the constants of precession, nutation and aberration that will be used on and after the year 1901.

The circular states the facts in regard to these constants so tersely and well, that we avail ourselves of its language, in the main, in what follows:

For many years past the American Ephemeris has used the following constants:

$$\begin{aligned} \text{Precession} &= 50.2411'' + 0.0002268'' \ (t - 1800) \\ \text{Nutation} &= 9.2231 \ + 0.000009 \ \ (t - 1800) \\ \text{Aberration} &= 20.4451 \end{aligned}$$

where $t$ is the year for which the constant is required. But at the "Conference Internationale des Étoiles Fondamentales," held in Paris in May 1896, it was recommended that on and after the year 1901 the Connaissance des Temps, the English Nautical Almanac, the Berliner Astronomisches Jahrbuch, and the American Nautical Almanac should abandon the above constants, and adopt in their stead the following new ones: Nutation $= 9.''21$, aberration $= 20.''47$, and for the precession, such value as might be decided on by Professor Simon Newcomb.

In the case of the American Ephemeris, Professor Newcomb has anticipated the recommendation of the conference by a whole year and has introduced the following constants into the volume for 1900:

$$\begin{aligned} \text{Precession} &= 50.2482'' + 0.000222'' \ (t - 1900) \\ \text{Nutation} &= 9.21 \ \ + 0.000009 \ \ (t - 1900) \\ \text{Aberration} &= 20.47 \end{aligned}$$

The old and new values for the year 1900 compare as follows:

| | Old Values. | New Values. | Differences. |
|---|---|---|---|
| Precession | 50.2638″ | 50.2482″ | − 0.0156″ |
| Nutation | 9.2231 | 9.21 | − 0.0131 |
| Aberration | 20.4451 | 20.47 | + 0.0249 |

While it is almost certain that the old constants will ultimately require small corrections, there is room for donbt as to whether or not these corrections can yet be satisfactorily determined, and it is evident that some very eminent astronmers are opposed to any departure from the old values at present. As the *American Ephemeris* is a government publication, it is desirable that it should be so conducted as to meet the wants of the astronomers of the country, and to that end Professor Harkness is anxious to ascertain whether they would prefer future almanacs to be based upon the old constants or upon the new ones. As the printing of the 1901 almanac will soon be commenced, and the constants to be used in it must be settled at once, he urges astronomers, at earliest convenience, to inform him which set of constants is preferred with a statement of the reasons for the choice.

That Professor Harkness should thus submit to astronomers generally so important a matter as the change of these constants is certainly a wise step, and astronomers should respond promptly that the information desired may be available.

**Ephemeris of d'Arrest's Periodic Comet.**—This comet was observed in June and July at Lick Observatory. It is slowly dimishing in brightness but is getting into more favorable position for observation. It is to be found in the morning in the constellation Taurus, about 15° south of the Hyades. The following ephemeris came to hand too late to be inserted in the usual place:

| | R. A. | | | Decl. | | log $\Delta$ | Brightness |
|---|---|---|---|---|---|---|---|
| | h | m | s | ° | ′ | | |
| Sept. 6 | 4 | 22 | 48 | + 1 | 57.3 | 0.1154 | 0.186 |
| 8 | | 24 | 34 | 1 | 38.6 | | |
| 10 | | 26 | 11 | 1 | 19.6 | | |
| 12 | | 27 | 38 | 1 | 0.2 | | |
| 14 | | 28 | 56 | 0 | 40.5 | 0.1097 | 0.179 |
| 16 | | 30 | 5 | 0 | 20.5 | | |
| 18 | | 31 | 4 | + 0 | 0.3 | | |
| 20 | | 31 | 52 | − 0 | 20.1 | | |
| 22 | | 32 | 31 | 0 | 40.7 | 0.1044 | 0.173 |
| 24 | | 33 | 0 | 1 | 1.4 | | |
| 26 | | 33 | 20 | 1 | 22.1 | | |
| 28 | | 33 | 30 | 1 | 42.8 | | |
| 30 | | 33 | 29 | 2 | 3.5 | 0.1002 | 0.166 |
| Oct. 2 | | 33 | 18 | 2 | 24.1 | | |
| 4 | 4 | 32 | 58 | − 2 | 44.5 | | |

**Annual Report of the Royal Observatory, Greenwich** —This report for the year ending May 10, 1897, by the Astronomer Royal, W. H. M. Christie, contains besides the usual routine matters, a brief account of the new Thompson equatorial. The new instrument, persented by Sir Henry Thompson, has been mounted in the Physical Observatory under the Lassell dome. It is a 26-inch photographic telescope with a $12\frac{3}{4}$-inch guiding telescope, and carries on the same mounting a 9-inch photoheliograph and a Cassegrain reflecting telescope of 30 inches aperture with a 6-inch guider.

The 28-inch equatorial has been used for the measurement of double stars and planets, and also, with the crown lens reversed, for photographic work. A number of photographs of the Moon and of the double stars Castor, ξ Ursæ Majoris, γ Leonis, Σ 1606, ζ Cancri and Σ 1877, show that the photographic correction of the object-glass by separation of the lenses and reversal of the crown is quite successful, and further, that certain classes of double stars can with advantage be observed photographically rather than visually.

**U Ophiuchi.**—I note Miss Proctor makes a slight misstatement as to U Ophiuchi in the July number, just received. The duration of the light-changes, which she gives as four hours, quoting blindly from Klein, is, according to Chandler and Sawyer independently, $5^h\ 20^m$; and these two have probably forgotten more about the star than all the rest of the astronomers, put together, ever knew. When one sets up as authority, it doesn't do to quote a popular publication as to variables—or anything else—without looking the thing up; and Chandler's Catalogues are still to be had. P. S. Y.

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**Variable Star Clusters**.—Announcement was made in circular No. 2 of the discovery by Professor Solon I. Bailey of numerous variable stars in certain globular stellar clusters, and their absence in other objects which apparently belong to the same class. Since then he has found many more of these variables, so that their total number including a few found here is now 310, distributed as follows: In N. G. C. 104 (47 Tucanae), 6; in 362, 8; in 1904, 1; in 5139 ($\omega$ Centauri), 60; in 5272 (Messier 3), 113; in 5904 (Messier 5), 63; in 5986, 1; in 6254, 1; in 6266, 9; in 6626, 3; in 6656, 5; in 6723, 2; in 6752, 1; in 7078, 27; in 7089, 8; and in 7099, 2. In the greater portion of these clusters about 1000 stars were examined. In Messier 3 about one ninth of the stars are variable while in others like N. G. C. 6205 (the great cluster in Hercules), out of nearly 2000 stars not a single variable has been found. The positions of 62 of the stars in Messier 5 are given in the Harvard Observatory Annals XXVI, 243, 246. The light curve and period of one of them are given in the *Astron. Nach.* CXL, 285.

SOUTHERN DOUBLE STARS.

A distinguishing feature of the climate of Arequipa is the great steadiness of the air. The value of this location as an observing station is largely due to this fact. Good definition, under high powers, is obtained there on many more nights than in Europe, or in the United States, where nine-tenths of the observatories of the world are at present located. A search for close double stars may, therefore, be advantageously made at Arequipa, and accordingly, in 1891 all the stars of the sixth magnitude and brighter, south of declination $-30°$, were examined for close companions. The stars in one quarter of the region, and included between $12^h$ and $18^h$ of right ascension were examined by Professor William H. Pickering, and the remaining three-quarters by Professor Solon I. Bailey. The instrument used was the 13-inch Boyden telescope. A power of 450 was ordinarily employed.

The stars whose numbers in the Argentine General Catalogue are given below were found to have companions whose distances were estimated not to exceed 30″. Stars already announced as double in the catalogues of Herschel and Russell are not included. When two or more companions were noted the letter T is inserted after the number:—

A. G. C. 451 T, 480 T, 684, 702, 780, 1024 T, 1197, 2412, 2992, 3487 T, 4368, 4395, 4845, 5295, 6494, 6633, 7914, 7990 T, 8093 T, 9234, 10188, 10335, 10496, 11097, 11712, 11727, 11887, 12035, 12101, 12180, 13135, 15795, 16200, 16541 T, 16612 T, 16690 T, 16793, 16845, 16992, 17403, 17440, 17504, 17541 T, 17572, 17907, 17936, 18174 T, 18492 T, 18700, 18773, 18863 T, 18931 T, 18980, 19129, 19273 T, 19280, 19295, 19540 T, 19578 T, 19597 T, 19679, 19697, 19741, 19746, 19873, 19916, 19934 T, 19980, 19988, 20049, 20170, 20203, 20444 T, 20466 T, 20649, 20695, 20806 T, 20811, 20861, 20909 T, 21078 T, 21153, 21177, 21319 T, 21374, 21421 T, 21499 T, 21559, 21694 T, 21767, 21828, 21887, 21921, 21974, 21995, 22124, 22159, 22534 T, 22582, 22598,

22604, 22949, 22970, 23018, 23035 T, 23098, 23126 T, 23358, 23397 T, 23448 T, 23486, 23515 T, 23549 T, 23597 T, 23603 T, 23785 T, 23973, 24148, 24182, 24218, 24407 T, 24483, 24557, 24570, 24624, 24703, 24888, 25137, 25259, 25527, 25548, 26026 T, 26041, 26287, 27354, 27909, 28851, 29314, 29368, 30425, 30814, and 32446.

SPECTRUM OF ζ PUPPIS.

In circular No. 16 it was shown that a line having wave length 5413.9 probably exists in the spectrum of this star. This line is clearly visible on three photographs of this star taken in Arequipa on isochromatic plates.

July 29, 1897. EDWARD C. PICKERING.

—HARVARD COLLEGE OBSERVATORY.

Circular No. 18.

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**Supplemental Notes for Professor Young's Book "The Sun."**—We have received a pamphlet of eleven pages from Professor C. A. Young, author of the work entitled "The Sun," which he has prepared in the form of supplemental notes to be appended to the next impression of the revision of 1895. We have asked of the publishers, D. Appeton & Co., the privilege to publishing these notes that our readers may have the benefit of them as soon as possible, for the matter they contain is very important. If such permit should not be given it ought to be said that amateurs using the spectroscope will find the first article, on the adjustment of the spectroscope, very helpful, because the directions there given are plain, full and quite complete.

Another note supplemental to page 81 in the edition above referred to, gives information in regard to the regularity and spacing of the lines of some of the elements of the spectrum. A striking instance is noted in the lines of the element hydrogen. They form a single series, beginning with the *C*-line in the red, then the *F*-line in the blue, then twenty more, as observed in the spectra of the Sun and stars, which are crowded more and more closely together as we reach the ultra violet region, their wave-lengths all being given by the one simple formula,

$$\lambda = 36461 \left( \frac{n^2}{n^2 - 16} \right),$$

in which $\lambda$ is the wave-length of a line on Rowland's scale, and $n$ is always one of the *even* numbers, 6, 8, 10, 12, etc., beginning with 6, because smaller numbers would give impossible results.

It is however a curious fact which is noticed in this connection, that certain stars give spectra whose lines are represented by assigning odd values to $n$ in the formula instead of the even, as, 5, 7, 9, 11, etc. That there are, in some elements, (as helium) more series than one, and that the series of other elements do not follow any known law are also commented on in the same connection.

The next article treats of the reversing stratum of the Sun and its spectrum and the spectrum of the corona. This matter is important in that it gives additional evidence of the correctness of Professor Young's theory of the existence of such a reversing layer which theory has not been accepted by some prominent English astronomers. Other notes will be presented later.

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**Astronomical and Physical Society of Toronto.**—At the meeting of July 20, in the course of a paper on Eclipses, Mr. Lindsay made a strong appeal

to the members of the society to begin early and to organize an expedition for the year 1900 when a total eclipse would be visible in the southern states. He said:

Some of our members are young enough to expect many opportunities to observe total eclipses, if expense of travelling is no obstacle; but others of us who will be hovering around the half-century mark when the new century dawns will feel that this is an opportunity that should not be lost; and there are others, already become full of years and honor who, revelling in the love of nature to the very last, will say that this is an opportunity that must not be lost. Whatever may be span allotted to these dear friends we will reverently trust that it will extend beyond the year 1900, and we will hope that they will live to remember that year as of the past; and bright with pleasant recollections. We can in fancy see one of these honored friends explaining a solar eclipse to a little one, two or three generations younger, and think we hear him say:

"Yes, my boy, I have seen a total eclipse of the Sun. It was during the last year of the last century, and we had formed a grand expedition in Toronto to go down to the cotton fields of Carolina, right in the track of the Moon's shadow. How I had looked forward to that event! I had seen and remembered celestial phenomena early in the century, long before the new astronomy began; I had seen the great meteor shower of 1832; the splendid comet of 1843 I had never forgotten; I remembered the brilliant work of Adams and Leverrier in the discovery of Neptune; the birth of the new astronomy when the stars gave up the secret of their constitution, I remember well; I had seen many transits of Mercury and the century's pair of transits of Venus; partial eclipses of the Sun, such as they had been, I had observed many times, but a total eclipse, that I had never dreamed of seeing, for the only reasonably possible one for me seemed so far ahead. But it pleased Heaven to spare me a little, and I only wish now I could describe to you the feelings that possessed me on the 28th of May in the year 1900. There we were, instruments all ready; telescopes, spectroscopes, cameras, everything; there we were, on a beautiful morning under the clearest sky that ever delighted the student of the stars. There we were, gazing up into the heavens and watching a black velvet disc eating its way into the glorious orb of day; then looking anxiously, fearfully, to the south-west, looking for the great blue-black shadow cone that we knew must soon envelope us. Smaller and smaller grew the rim of light, and an indescribable sense of awe possessed us; tick, tick, went the chronometer that was to mark the instant of totality; tick, once again, a sharp signal announcing that the exact computed moment had arrived—and the shadow was upon us! A feeling of nameless dread possessed me; in such utter blackness it seemed as if for me the whole universe had been blotted out. Then I looked up and in that instant there flashed out as a halo around an inky black disc—the Sun's corona, that object of transcending beauty, which neither camera nor pencil can delineate, and the language of poetry but feebly describe. For two short minutes I drank in the beauty of the spectacle, feeling indeed that I was in the presence of the Infinite, then it was gone, as quickly as it came. I had done nothing but look, awe-stricken, powerless to use any sense but one. But some there were with us, denying themselves the rare two minutes for mere observation, who employed every second in interrogating nature, and you know, my boy, that it is recorded in your books that all questions relating to the Sun's corona were finally set at rest by the Toronto Eclipse Expedition."

Some such a picture, friends, look forward to; and let me ask you now, "Who will join the expedition?"

**Astronomy at The University of Chicago.**—Courses in Astrophysics, machine designing and observational work will be given at the Yerkes Observatory at Williams Bay, under the direction of Professors Hale and Wadsworth. At the University the following courses are announced for the Autumn Quarter, beginning October 1st.

1. *Analytical Mechanics.* This course continues through two quarters and is adapted to students in Astronomy, Math. and Physics. Recitations 4 hours per week at 8:30. Prerequisites: Differential and Integral Calculus.

2. *The motion of a heavenly body in a resisting medium.* Lectures 4 hours per week at 9:30. Prerequisites: Theory of Orbits and Differential Equations.

3. *General Astronomy.* A course offered to Senior College Students in general and descriptive astronomy. Recitations 5 hours per week at 11:00. Prerequisites: Solid Geometry and Trigonometry.

Dr. Laves will take a vacation during the Autumn Quarter but will offer courses during the remainder of the year. F. R. MOULTON.

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**E. E. Barnard** of Yerkes Observatory, Williams Bay, Wisconsin, was elected Vice President of section A. (Mathematics and Astronomy) at the last meeting of the American Association for the Advancement of Science.

We notice also, with interest, that the British Nautical Almanac uses his value for the diameter of the planet Neptune.

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**Brilliant Meteor.**—On Sunday evening Aug. 8, about 7 o'clock and 30 minutes, being on the east side of our house, we saw a meteor as large and about as brilliant as the half-moon, moving rather slowly northward in the heavens (or a little west of north). In shape it was somewhat like a very short lamp chimney. It was perhaps 3° to 5° from the zenith. No sparkling was seen; no noise heard. P. B. F.

Lyndon, Vt. Aug. 9, 1897.

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**Atlas of the Uranometria Argentina.**—Copies of this celestial atlas are for sale at $6.00, and can be obtained by addressing the *Astronomical Journal*, Cambridge, Mass. This well known work consists of thirteen large charts, with a fourteenth index-chart, on which are depicted accurately the positions and magnitudes of about 8,000 stars, to the seventh magnitude, between 12° north declination and the South Pole. Of these nearly 6,000 are visible above the horizon in mean latitudes of the United States. It is almost indispensable to the astronomer, professional or amateur, whether employed in observation with the telescope, field or opera-glass or naked eye; and especially so to those interested in the observation or detection of variable stars.

It will be sent, free of postage or express, on receipt of order, accompanied by remittance in postal money order or check payable to the *Astronomical Journal*.

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**For Sale.**—An 8½-inch silver-on-glass telescope made by J. A. Brashear. It has a fine speculum, diagonal mirror, iron tube, rack and pinion for eye-end, finder, two eyepieces and cradle bar so tube can be rotated. It will be sold cheap as owner has purchased a more powerful telescope and has no use for two instruments. Address L. A. T., 314 Walnut St., Danville, Ill.

**The Astrographic Chart.**—The article entitled as above in our June number should have been credited to F. W. Dyson instead of F. W. Denning.

**For Sale.**—A new 6-in. equatorial mounting, with circles, etc. (Class B. of W. and D. Mogey, Bayonne City, N. J.) Address M. A. Bigelow, No. 11, Pleasant St., Stamford, Conn.

**For Sale Very Cheap,** a Brashear 8½- inch mirror and flat, two eyepieces, mount with rack and pinion. The mirror is perfect, every way as good as new so far as we know, being just re silvered by Mr. Brashear. Inquire at the office of POPULAR ASTRONOMY.

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